

# Motorcycle Carburettor Manual

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by Pete Shoemark

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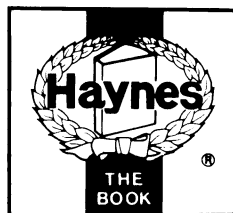
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# Introduction

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There can be few motorcyclists who have not been confronted by carburation problems in one form or another. The number of symptoms which can be attributed to some sort of carburettor malfunction is just short of infinite, and this often leads to some tentative screwdriver-twiddling on the part of the owner, in the vain hope that this will resolve the problem. Unfortunately, unless he is very lucky indeed, this will only add another discrepancy, and will often mask the true cause of the original problem. Given that many machines possess four or more carburettors, this can lead to a very interesting tangle, and can take hours to sort out.

The root of the problem lies in the very nature of carburation. It is a rather esoteric process involving the passage of various fluids through numerous small holes. In short, a carburettor fault can rarely be seen or measured. Most riders could diagnose a slipping clutch with the utmost ease, and the resulting investigation will reveal measurable wear or damage. But when it comes to that annoying flat spot at 3000 rpm in 5th .....

This book will not show you how to measure the size of a

main jet – carburation is never that straightforward. The key to successful carburettor timing and rebuilds is an intuitive approach, most of the fault diagnosis being done from the saddle rather than in the workshop. To this end, it is essential that what goes on in all those drillings, jets, air bleeds and passages is understood, both as separate systems and as one aspect of a rather complicated precision device. Consequently, a large proportion of this book deals with the requirements of carburation and the various ways in which the hundreds of examples of carburettors meet them.

The chapters relating to tuning are divided into the three basic types, these being Slide, Constant Depression and Fixed Jet. Further chapters relate to overhaul, specific variations from the common designs, and to tuning aids and equipment.

It is hoped that this book will lead to a better understanding of carburettors and of the ways in which the various types set out to solve common problems in a variety of ways. Armed with this, carburettor tuning should become far less mysterious and much more accurate.

# Acknowledgements

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# Chapter 1

## The Demands and the Developments

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### 1 The role of the carburettor

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Every motorcycle engine, from the simple single-cylinder two-stroke, to the most sophisticated multi-cylinder four-stroke, is dependent on two very precise pieces of ancillary equipment. The first of these, the ignition system, is of obvious importance because it supplies the exactly-timed spark which ensures that combustion occurs at precisely the right moment. The second piece of equipment can fairly be considered to be of even greater importance, for without it, the engine cannot be run or controlled. It is, of course the carburettor.

During every engine cycle, be it two- or four-stroke, the carburettor must feed the engine with a precise amount of fuel, mixed with an equally precise amount of air. Moreover, as loading on the engine varies, this fuel mixture must be varied to compensate.

When the engine is cold the ratio of fuel to air must be altered radically; when idling, the carburettor must function automatically; and when it is wished to increase the speed of the engine, some means of controlling the carburettor's operation to fine limits must be contrived.

It will already be apparent that the carburettor must be capable of performing a wide range of functions with great accuracy and consistency, allowing induction to take place as often as ten thousand times every minute or even more. Equally important, it must be robust, to endure extremes of temperature and vibration and wide variations of climate.

It is not surprising, therefore, that the instrument that we tend to accept today without a second thought has taken almost a century to evolve. The earliest carburettors were crude and inefficient and were a major limitation in producing useful amounts of power from early engines. This problem was painfully evident to the early engine designers, and from the plethora of carburettor designs there soon emerged the recognisable ancestors of the three basic designs in common use today. The intervening years have provided ample opportunity for refinement and improvement.

It is not unreasonable to say that the carburettor is amongst the most highly developed aspects of the internal combustion engine. Having conquered the fundamental problems of supplying a combustible mixture to the engine, the carburettor manufacturers were obliged to engage themselves in a relentless search for sophistication. It was obvious that the motorcycle manufacturer would choose only those instruments which made the most of his machine, and despite widely conflicting demands, only a few specialised carburettor companies have survived to this day.

There is a tendency to assume that carburettor develop-

ment must by now have reached a peak. This is far from the truth, because the energy crisis which began to become apparent during the 1970s has made it necessary to produce a most frugal instrument, but one which is still capable of allowing a high engine power output. In this way, the two most contradictory requirements have been heavily underlined. The carburettor may be almost perfect, but the search for perfection continues.

As motorcycle design moves into the 1980s, it has become increasingly difficult for the manufacturer to produce the right product. In the earliest days of motorcycling, the *only route* to obtaining power was by means of large capacity engines. By 1960, engine and carburettor design had seen engine capacity fall by almost half, and 650 cc machines, the 'big' capacity models of that era, were able to combine a high maximum speed with reasonable fuel consumption. Since the late 1960s, engine capacity has climbed once more in the search for more and more power. This new generation of large capacity machines, mostly four- or six-cylinder four-strokes, are not the simple low-efficiency devices of the 1920s. Engine development has seen single or double overhead camshafts become the norm on roadsters, and such high performance engines have a thirst commensurate with their specification.

Increasing concern about the effects of atmospheric pollution and the earth's rapidly dwindling oil stocks has placed the already hard-pressed carburettor in a position where it is forced to play an even more demanding role. It is the conflicting demands of a public who require a motorcycle to perform better, using less fuel and producing the minimum of pollution, which have pushed the simple slide-type carburettor to its limits, and have brought about the introduction of a promising newcomer to motorcycles, the CD (constant depression) or CV (constant vacuum) instrument.

Future developments in carburation are difficult to predict. The conflicting demands mentioned previously are ultimately impossible to resolve, and development of existing types will almost certainly be as a result of a change of emphasis of these requirements. A more economical machine is quite feasible, but power outputs must fall accordingly.

Alternatives are not numerous. The fixed-jet carburettor, still favoured by the car manufacturers, has not generally found a receptive home on the motorcycle. It has a number of drawbacks, amongst them cost and fuel economy considerations, and it seems unlikely that this type of instrument has much future where motorcycles are concerned.

The only obvious innovation may be fuel injection. This system does not constitute carburation in the accepted sense, and has yet to prove itself as a commercial success. On both

counts, it is not the concern of this book, but it may well be the shape of things to come. The basic principles of fuel injection are discussed briefly elsewhere in this book.

To understand the various types of carburettor used on modern motorcycles, it is important to understand first what is required of this instrument, and how this can be accommodated by the basic, theoretical, carburettor. Do not be tempted to skip this part of the book and move on to the practicalities of the various types – the theory is essential to tuning, as it is important to understand exactly what effect any adjustment may have, and why this should be so. Armed with this understanding, attempts at tuning will become more intuitive and accurate. Trial-and-error can only be more costly and time consuming in the end.

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## 2 Fuels

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This book will concentrate almost solely on petrol, or gasoline, as a fuel. This is simply because it is almost exclusively used as the power source for road-going machines. When asked why this should be the case, it is tempting to reply that petrol is easily obtainable. This really only states that petrol is generally accepted as a good all-round fuel for road use. If this were not the case, we might have pumps on garage forecourts to serve us with paraffin (kerosene) LPG (liquid petroleum gas) or any one of a number of petroleum fractions.

The liquid that is pumped into our fuel tanks – ‘petrol’ or ‘gasoline’, depending on one’s location in the world – tends to get dismissed with no thought given to why it is used or from where it is obtained. The beginning of the story is that increasingly valuable commodity, crude oil. This is extracted in numerous places around the world and shipped or piped to oil refineries for processing. It is of such importance that its price and availability is a major factor in the world’s economics.

Crude oil is a thick black substance, and it can be rather difficult to relate the black tarry mess which washes up on our beaches from time-to-time, with the aromatic liquid that got us to the beach in the first place.

Crude oil is broken down by distillation in oil refineries, to produce the numerous oil-based products that we use every day. In a simplified form, what happens is this: the crude oil is heated at the base of a large tower, causing it to evaporate and move upwards. The tower is divided into galleries which are maintained at fixed temperatures, becoming progressively cooler towards the top. The lightest fractions of the crude oil remain gaseous until they reach the top of the tower, the remaining, less volatile, compounds condensing at progressively lower levels, and at higher temperatures. The condensates are then drawn off from the separate levels.

What we require at the petrol pump must fulfil a number of conflicting criteria. The fuel must have a moderately high **Calorific Value**, or **CV**. This is the amount of heat energy per unit of fuel, and within limits, the higher this factor is, the more is the work that can be obtained from a given amount of fuel. Unfortunately, the higher the CV, the higher the density of the fuel, and consequently, the lower its **Volatility**. A highly volatile liquid is one which will evaporate readily at comparatively low temperatures, and this is in practice at the other end of the range to the fuels of a high CV. So it can be seen that the choice of fuels has been narrowed considerably, and must lie as a compromise between a fuel of high CV and one of high volatility. A third factor which influences the choice of fuel is its resistance to **Detonation**, or self-ignition under pressure. Because fuels are inevitably compressed in the cylinder, low anti-knock characteristics must be avoided at all costs. Detonation will happen when a high-compression engine is run on low-grade fuel, and will ultimately destroy the engine.

Given the foregoing requirements, we find ourselves with common pump petrol, or gasoline, as the obvious choice for our fuel. There are a number of good alternatives, but these can largely be ruled out on grounds of cost or convenience. The question of fuel choice is in fact a good deal more complicated

than has been explained, but as this book relates to carburettors rather than fuel, and to keep the subject as digestible as possible, further exploration of this rather involved subject will be avoided.

Having found a good fuel, it is necessary to mix it with a suitable amount of air to achieve efficient combustion. It can be demonstrated that any given quantity of fuel will require a fixed proportion of air to effect full combustion. This ratio is of vital importance, as a significant variation either way will result in wasted potential on each power stroke. If excess air is admitted, a proportionately smaller amount of fuel can be admitted, and consequently, power is less than is possible. Conversely, if too much fuel is fed to the engine, there will not be sufficient air to allow it to be burnt, and again, power is lost.

These two extremes are what are known respectively as weakness or richness. There is, naturally enough, a position between these extremes where the mixture is correctly balanced. In practice, this is a ratio of fifteen units of air to every one of fuel, or 15:1, as an optimum balance between performance and economy. The absolute practical limits are between 12:1 and 18:1, and the mixture can be varied between these two ratios to obtain either better performance or economy.

The implications of an extremely weak or extremely rich mixture are more significant than might at first be suspected. Most motorcyclists will be vaguely aware that these conditions do little to enhance an engine’s longevity, but may not know exactly what goes on inside the cylinder in these circumstances.

When an engine is run with a weak mixture, the sparsity of fuel in the combustion space means that the time taken for combustion is longer. The flame front spreads relatively slowly, and may even still be burning as the piston reaches the bottom of its stroke. This causes the engine to run abnormally hot (due to the increased time available for heat transfer to the cylinder components) and, in extreme cases, the valves on four-stroke engines, and the pistons on two- or four-stroke engines, may become burned. Two-stroke engines are particularly susceptible to weak mixtures, and it is this and incorrect ignition timing which is the main cause of holed pistons.

With an over rich mixture, carbon build-up within the engine becomes greatly accelerated, and frequent fouling of the sparking plug is often evident. In extreme cases ‘fuel-wash’, a condition where the excess petrol dilutes the oil film on the cylinder walls, can cause premature wear or even seizure.

Other effects of incorrect mixture ratios are the emission of increased quantities of toxic gases from the engine’s exhaust. This factor is of growing significance now that laws governing exhaust emission have been passed in many countries. It is obvious that a rich mixture will result in poor fuel economy, but perhaps surprising that a weak mixture can have the same result due to the inefficiency of the engine in these conditions.

It will be appreciated from the foregoing that it is essential that the fuel-air ratio is maintained to fine tolerances if the engine is to operate efficiently. When an engine type is first built carburation is a major factor in subsequent development and testing. Most manufacturers now use sophisticated equipment which electronically analyses the exhaust gases, thus assessing the mixture strength very accurately. This is normally done in conjunction with a rolling road, and thus the carburettor can be chosen, adjusted and tuned very accurately indeed in the development workshop.

Scaled-down versions of these complex diagnostic machines are now in common use in large motorcycle dealers, enabling the mechanic to tune the engine to perfection, when used astutely. This equipment is complex, bulky and frighteningly expensive, but by no means essential to the home mechanic. In many cases the same degree of accuracy can be obtained by less glamorous means, even if it does take a bit longer. It is amusing to note that an article in a British motorcycle magazine found that the ignition timing on their test machine could be set using a slip of cigarette paper with the same degree of accuracy as a diagnostic machine costing several thousands of pounds. The same can be applied to tuning and maintaining carburettors.

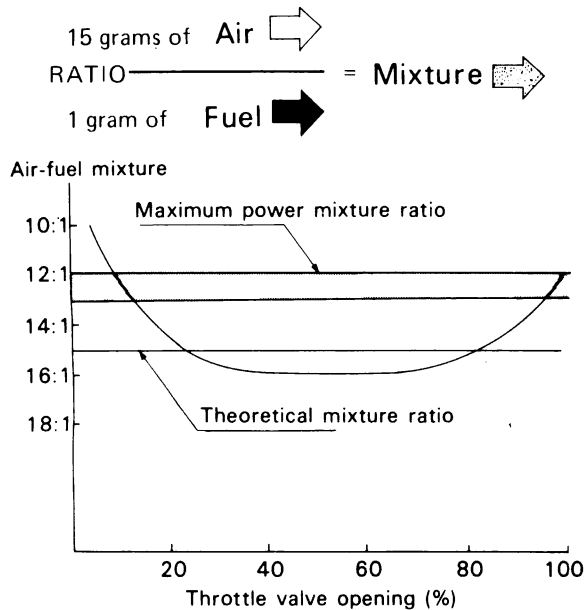


Fig. 1.1 Typical air/fuel ratio curve for slide carburettor

This curve illustrates how the carburettor is set up to give a reasonable compromise between maximum power and maximum economy. From a mixture ratio which is rich at tickover, the curve moves quickly to a much weaker range for most of the throttle opening range. Note that at large throttle openings the ratio moves back towards richness.

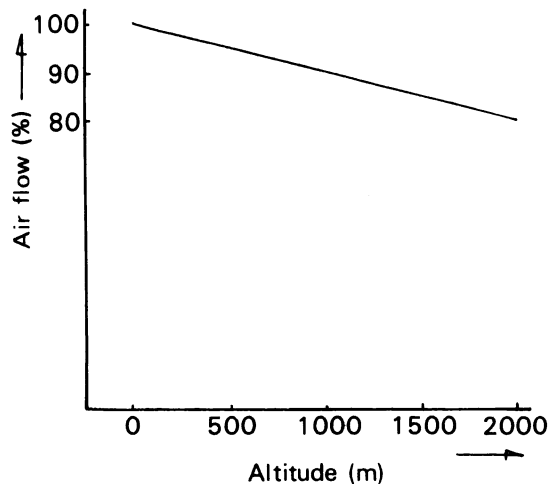


Fig. 1.2 The effect of altitude on mixture strength

Note how a 100% air flow rate drops by roughly 10% per 1000 feet. Carburettors can cope with most normal variations, but may require re-jetting to compensate for constant high-altitude work.

### 3 A theoretical design

Every type of carburettor in current use on motorcycles exploits in its design a common principle of fluid dynamics. This basic design shape is known as a venturi. The venturi is simply a tube with a convex internal bore, so that air passing through the

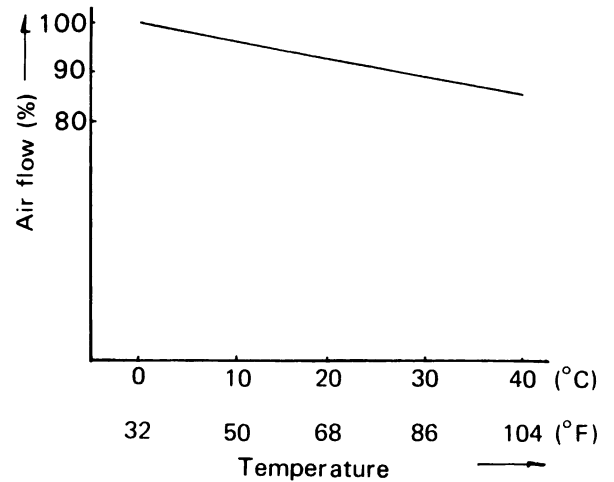


Fig. 1.3 The effect of ambient temperature on mixture strength

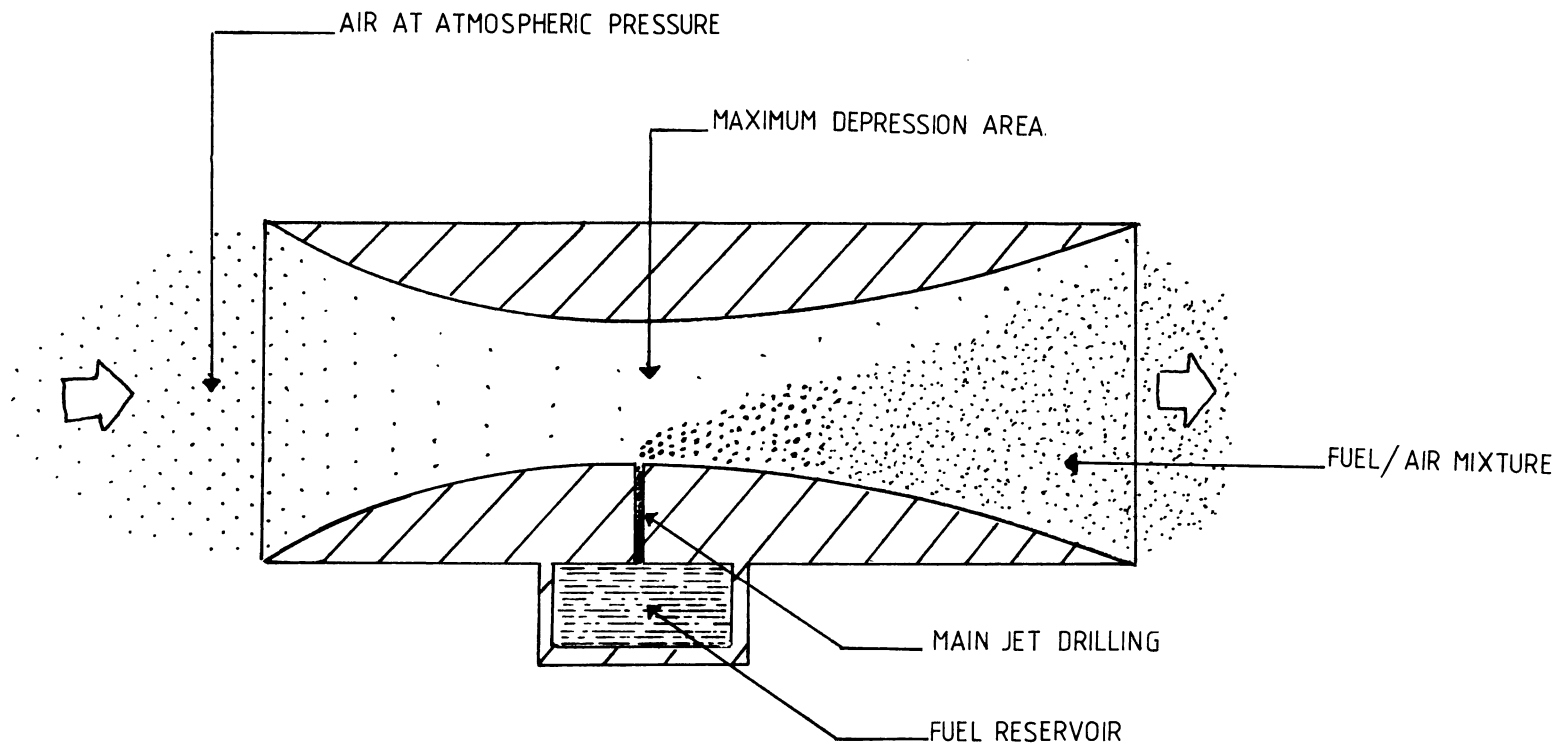
The chart represents the normal variation in percentage air flow that can be expected under normal operating conditions. The carburettor must be able to cope with this 10% – 15% range.

tube is progressively restricted after which the bore slowly returns to its original diameter. The result of this is that the velocity, or speed, of air passing through the venturi will gradually increase as it approaches the most constricted part, reach a peak at the point of maximum constriction, and then slow down again. Air, like water, is considered a fluid, and the two behave similarly in these conditions. A similar situation can be seen in rivers; the water flowing through a broad, unobstructed channel will move relatively slowly, but when it meets an obstruction, or narrow banks, it is forced to flow more quickly to pass the same volume of water through a restricted section.

Returning to the basic venturi, we find that not only does the narrowest part of the section, the throat, produce an increased speed, but also that the pressure at this point is reduced. This is because the pressure exerted by a fluid, in conditions such as these, is inversely proportional to its velocity, meaning that pressure decreases as speed increases. If a hole were drilled through the wall of the venturi at the throat, air would rush in through the hole to attempt to balance the pressure differential that exists between the throat of the venturi and the outside atmosphere.

If we connect a pipe to this drilling and connect it to a reservoir of petrol having a level slightly lower than the outlet into the venturi, we have, in effect, a basic carburettor. Naturally, the fuel must be maintained at a constant height or the rate of delivery would vary, so the reservoir must incorporate a valve operated by a float to control this. To control the speed of the engine, it will be necessary to contrive some means of slowing the air flow through the venturi by partially obstructing it at some point.

It will be seen that we have now constructed a basic carburettor, complete with throttle control and an automatically regulating float chamber. This relatively crude instrument would in fact work up to a point, but it does have certain failings which have necessitated slight complications to obtain accurate control of the air/fuel ratio. At this point, the design of carburettors splits up into various types, each of which seeks to overcome these basic failings in a number of different ways. In the next chapter, the various types will be discussed in detail, but it is worth remembering that all are descendants of the simple venturi-based instrument.



**Fig. 1.4 The theoretical carburettor**

*This is a cross-sectional view of a simple venturi. The drilling is positioned at the point of maximum constriction, and thus at the point of lowest pressure. Fuel is drawn up from the reservoir and emerges in the form of an atomised spray. Here it mixes with the air flowing through the venturi, forming a combustible fuel/air mixture. With the addition of a simple butterfly or plate throttle, this basic instrument would prove quite adequate for use on a stationary engine or lawnmower, although it would require more sophisticated jetting for motorcycle application.*

## Chapter 2 Carburettor types

In Chapter 1, the various requirements of the engine were discussed, and from this a basic theoretical carburettor was contrived. As mentioned previously, this simple instrument has a number of inherent problems, most of which are a direct result of the need for the instrument to operate under constantly changing engine loads and throttle settings.

One of the first problems encountered is that of starting the engine. When the engine is cold, the petrol is far less inclined to vaporise as it enters the inlet tract. What tends to happen is that the petrol condenses on the cold metal surfaces, and thus a richened mixture is necessary to achieve combustion. The simplest way to accomplish this is to restrict the airflow through the carburettor. This is done by obstructing the carburettor bore with a slide or similar device, and in effect this enhances the venturi effect, causing a greater volume of fuel to be drawn into the engine for a given amount of air, giving the fuel-rich mixture required for cold starting. This system, widely known as a choke or strangler for obvious reasons, has been used successfully for many years, and the term 'choke' is often applied to all cold starting systems, including those which do not use the above principle. Indeed, so confusing is the term 'choke' when dealing with carburettors, that its use here has been avoided as far as possible.

Another type of starting system is the mixture richening arrangement, whereby a plunger in the carburettor body brings into operation a separate pilot or starting system which delivers the correct petrol-air mixture independently of the main circuit.

Once the engine has been started, and begins to warm up, the petrol will vaporise more readily and the richened mixture will soon become apparent. Unless the cold starting device is turned off, the engine will flood and stall.

To alter the engine speed, the volume of air passing through the instrument must be controlled, either by a butterfly valve, or more commonly, by the use of a throttle slide or valve. In the first type, a butterfly valve, consisting of a circular metal disc pivoted on the engine side of the venturi, is connected to the throttle twistgrip, by means of which it can be opened or closed to control airflow through the carburettor bore. Because the venturi profile is maintained over all throttle settings, this arrangement is termed **Fixed Venturi** or more commonly, **Fixed-Jet**. This type of carburettor, although used widely on car engines, is virtually unknown on motorcycles. A notable exception to this is Harley-Davidson, who favoured this type of instrument until quite recently.

The slide carburettor, as it is commonly known, is one type of **Variable Venturi** instrument, so called because the venturi profile of the bore is largely replaced by a movable obstruction in the form of a circular throttle valve or a flat slide. In all but the smallest of instruments, the variable venturi type will require some means of varying the rate at which the fuel flows through the main jet and into the carburettor bore. This is normally done by attaching a long, tapered needle to the bottom of the throttle valve, so that it enters a carefully sized tube, or needle jet, directly above the main jet.

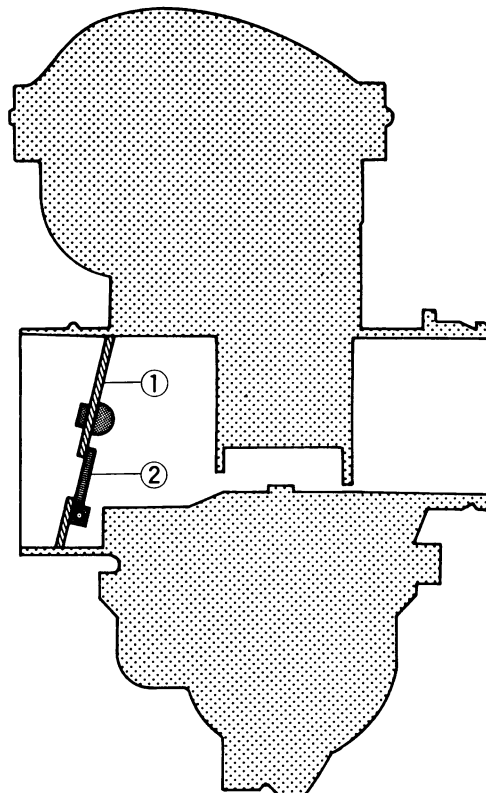
At small throttle openings the airflow through the instrument is low, and because the tapered needle almost closes the needle jet, the rate at which petrol is admitted is restricted accordingly. As the throttle is opened, the airflow increases, and the needle valve admits more petrol, thus maintaining the correct ratio at various throttle settings.

Another type of variable venturi carburettor is the constant depression (CD) type. This is a development of the simple slide

type in which engine speed is controlled by a butterfly valve on the engine side of the main bore. The throttle valve is developed into a piston which moves up or down in response to the changing vacuum effect. In this way the CD instrument is an automatic self-throttling version of the slide carburettor.

These then are the three basic configurations found in current motorcycle applications. The fixed-jet or fixed venturi types are fairly unusual, and the most popular type by far is the slide instrument. The CD type is fast gaining popularity, as it allows a much closer control of exhaust emissions to be maintained. For this reason, it is likely that there will be a very significant swing in favour of these instruments in the coming years, and they may well replace the slide carburettor as the standard fitment in the near future.

In the Chapters that follow we will investigate the three basic types in greater detail. It is recommended that the Chapters on each type are read carefully to understand how each system sets out to solve similar problems in various ways.

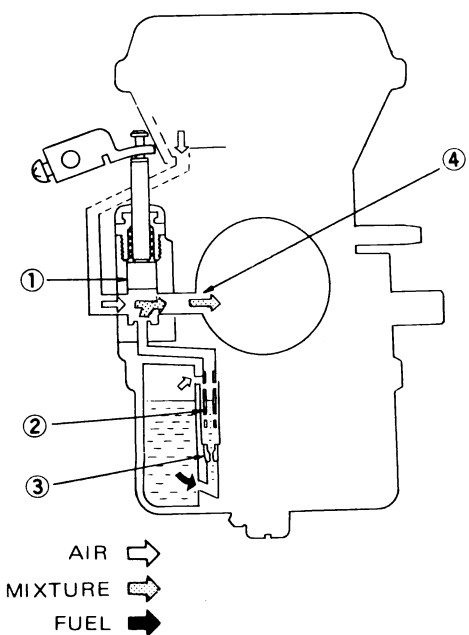


(Courtesy of Kawasaki Motors (UK) Ltd)

Fig. 2.1 A typical strangler or 'choke' mechanism

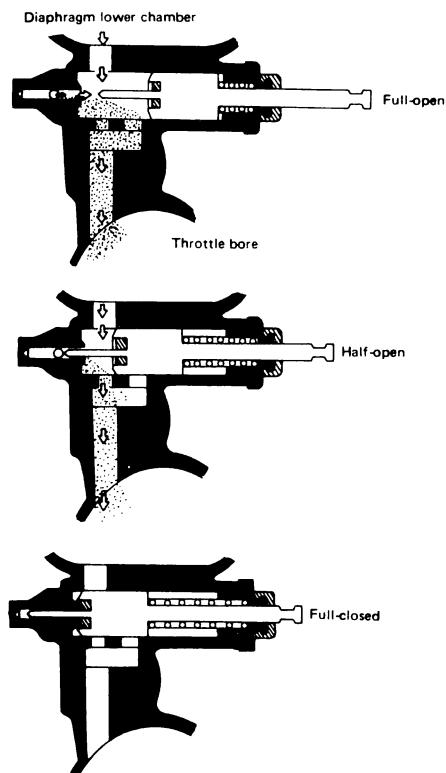
*A butterfly valve (1) is closed, partially obstructing the carburettor bore and giving an extremely rich mixture – often as much as 1:1 for cold starts. A relief flap valve (2) will open automatically against spring pressure to prevent the air supply becoming totally cut off.*





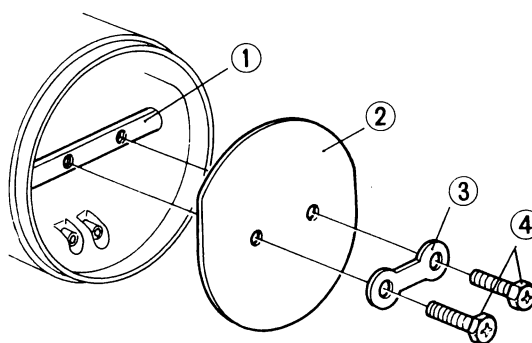
**Fig. 2.2 A typical mixture-richening cold-start system**

Fuel from the float bowl is drawn through the starting jet (3) where it passes into an emulsifying tube (2). The resulting frothy fuel emerges and is vaporised in the air flowing to the main bore through the cold-start drilling (4). The system is controlled by an on-off plunger (1).



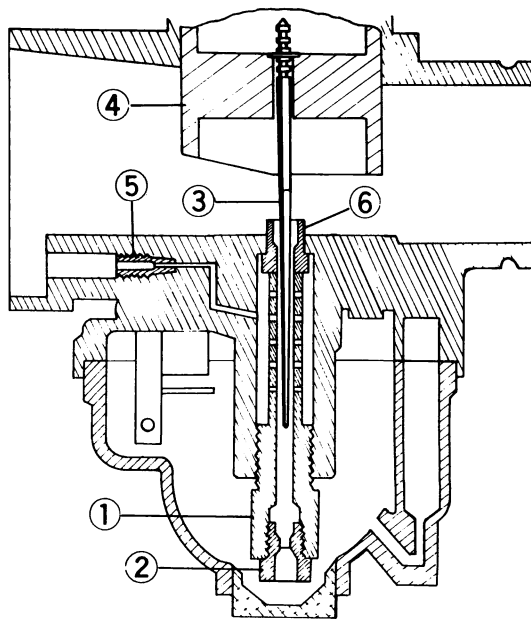
**Fig. 2.3 A two stage cold-start circuit**

With the plunger fully open, a rich starting mixture is drawn down to the carburettor bore for initial starting. As the engine begins to warm up, the plunger is returned to the half-open setting where a slightly weaker mixture is produced. When pushed back to the closed position, the plunger blocks off the air and fuel circuits.



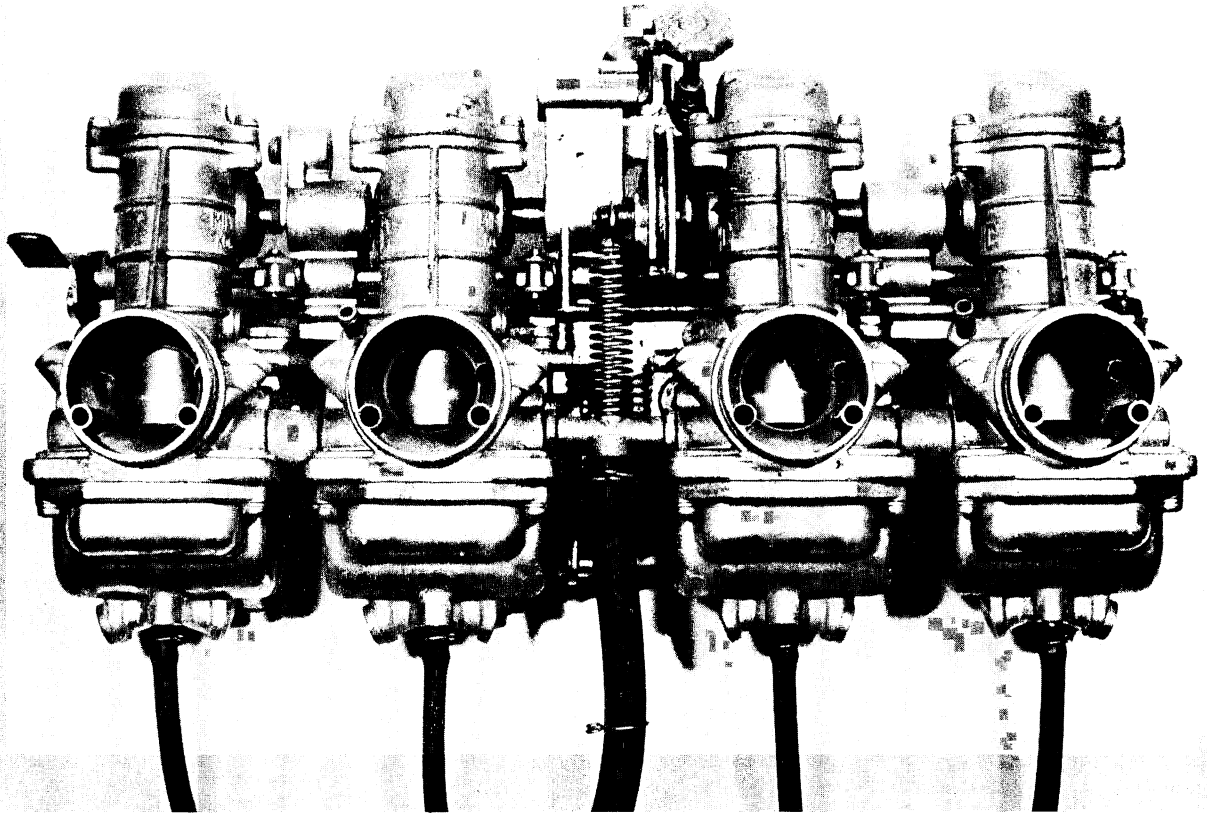
**Fig. 2.4 A typical butterfly throttle valve**

This type of valve is widely used on fixed-jet and CD carburettors. A rotating spindle (1) carries the circular plate, or butterfly valve (2) which is normally retained by screws (4) and a tab washer (3).



**Fig. 2.5 A typical throttle valve - slide carburetors**

The cylindrical throttle valve (4) controls the airflow through the instrument. Fuel is drawn through the main jet (2) and into the emulsion tube (1) where it is mixed with air drawn from the air jet (5). At all but idle and full throttle, the needle (3) and needle jet (6) control the fuel flow into the main bore.



**Bank of four slide carburetors – Mikuni VM24SS fitted to Kawasaki Z650**

# Chapter 3 The Slide Carburettor

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Operating principles .....	2		

### 1 Introduction

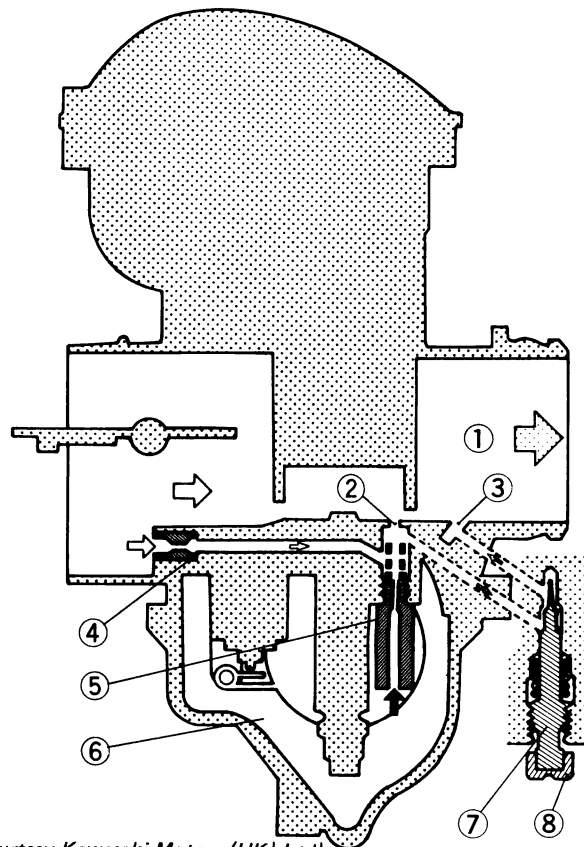
The slide carburettor, or variable venturi carburettor as it is more properly known, can fairly be said to be the most popular motorcycle instrument. Although the CD (constant depression) instrument is gaining in popularity, the ubiquitous slide type device is likely to remain popular for some years yet.

As described earlier, the slide carburettor employs a circular valve or flat slide to vary the venturi effect in the bore, together with a needle valve arrangement which meters the fuel accordingly. The operation of all slide carburetors can be broken down into four approximate divisions as follows.

### 2 Operating principles

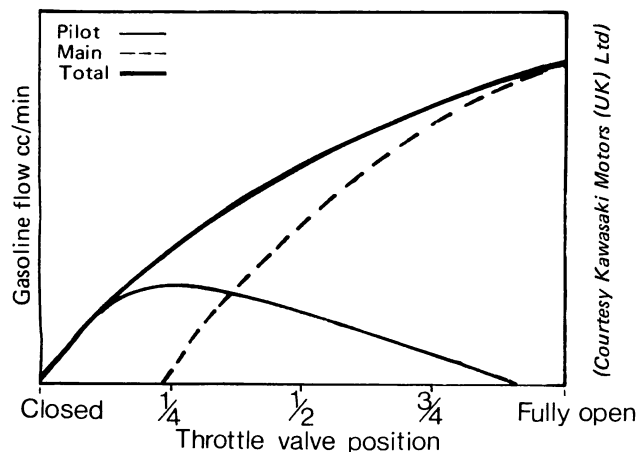
#### The pilot system

From tick-over to roughly  $\frac{1}{8}$  throttle, the carburettor depends heavily on the pilot system. Fuel from the float chamber is drawn through the pilot jet, and into the pilot air passage. As the throttle valve is almost closed, depression at the engine side is high, and air is drawn through the pilot air passage with considerable force. The rate at which the air flows is regulated by the pilot air adjusting screw, which, in combination with the pilot jet, allows the correct mixture for tick-over (idle) to be obtained. As the throttle is opened, the effect of the pilot system gradually diminishes, to be taken over by other factors. Almost all slide-type instruments conform to the above arrangement. Exceptions are the simple slide carburetors on small two-stroke engines, in which no adjustment is provided, this being pre-set during manufacture. The principle of the pilot system remains the same, however.



(Courtesy Kawasaki Motors (UK) Ltd)

Fig. 3.2 Typical pilot system

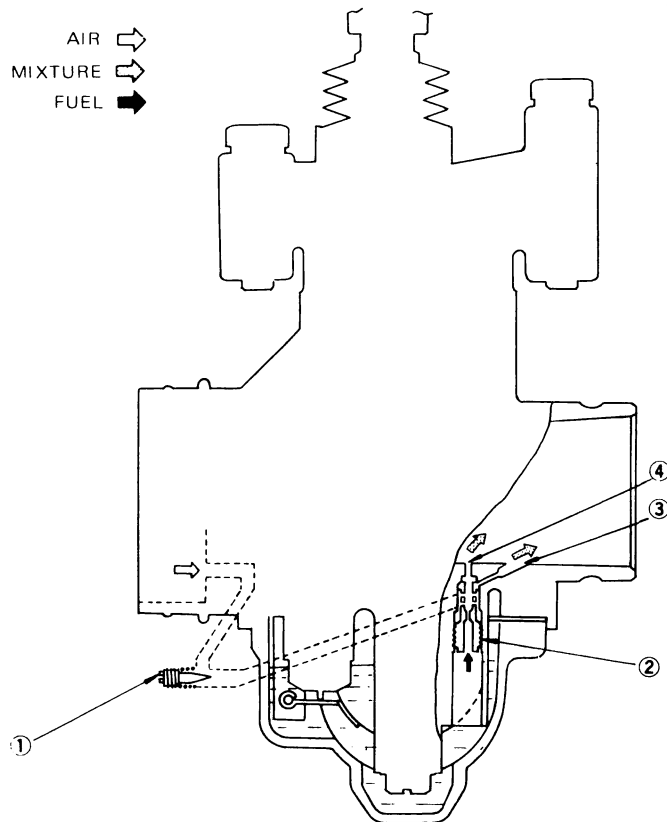


(Courtesy Kawasaki Motors (UK) Ltd)

At idle and low speed, the throttle valve is just open and a high pressure exists on the engine side of the valve (1). Fuel is drawn through, and metered by, the pilot jet (5) and is then mixed with air drawn through the pilot air jet (4). A set amount exits into the bore via the bypass outlet (2) whilst a degree of mixture control is afforded by the pilot screw (7). This discharges through the pilot outlet (3). (6) indicates the float chamber, whilst (8) is the plastic limiter cap which prevents mixture adjustment beyond prescribed levels.

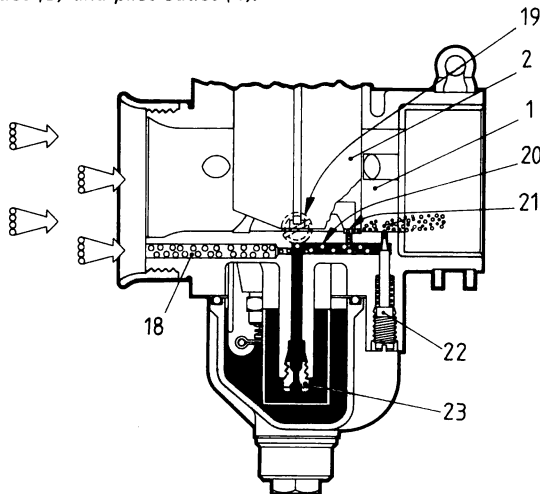
Fig. 3.1 Pilot system effect throughout throttle range

Note that there is no fixed point at which the pilot system ceases to have effect. As the throttle opens progressively, the pilot system's contribution gradually tails off.



**Fig. 3.3 Pilot system – Mikuni VM24SC/VM28SC as fitted to Suzuki GT380L and GT550L**

A pilot air screw (1) controls the air flow to the area above the pilot jet (2). The pilot mixture is discharged via the bypass outlet (3) and pilot outlet (4).



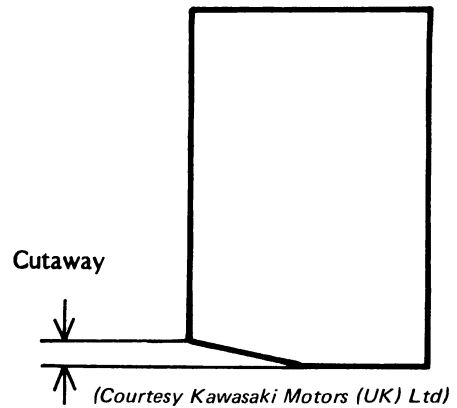
**Fig. 3.4 Pilot system – Dellorto PHB types**

Fuel is drawn from the float bowl through the pilot jet (23) where it meets air flowing through the air inlet passage (18). The resulting mixture flows along the passage (20) to the pilot mixture screw (22). The regulated mixture is then discharged into the main bore (1) immediately behind the throttle valve (2).

During the transition from idle to the main circuit, the emulsified mixture also discharges through the pilot bypass (21). The position of the throttle valve at idle is controlled by the throttle stop screw (19) shown in outline.

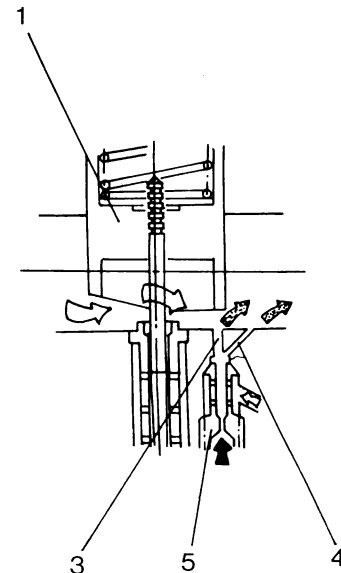
**Throttle valve cut-away**

The throttle valve has a cut-away on the atmospheric, or inlet, side. The depth of the cut-away influences the degree of depression acting upon the main jet, and affects the air/fuel ratio mainly between  $\frac{1}{8}$  and  $\frac{1}{4}$  throttle opening. In practice, the cut-away is considered to control the stage where the pilot system's effect is dropping off, and prior to the needle and needle valve's period of control. As can be imagined, a small cut-away will give a rich mixture, whilst progressively larger cut-aways will result in a correspondingly weaker mixture.



**Fig. 3.5 Throttle valve cut-away**

Size of cut-away influences mixture during transition from pilot to main fuel system – approximately  $\frac{1}{8}$  –  $\frac{1}{4}$  throttle.



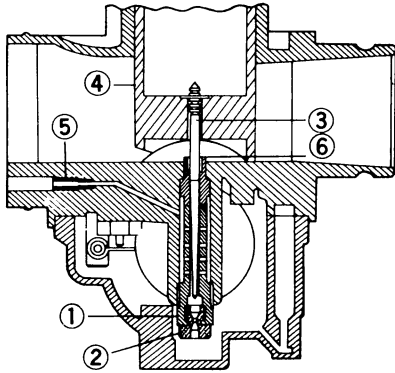
**Fig. 3.6 Effect of throttle valve cut-away**

The throttle valve (1) is at the  $\frac{1}{8}$  –  $\frac{1}{4}$  open position, allowing a moderate airflow beneath it. The effect of the pilot outlet (4) has diminished, and fuel flow is now primarily through the pilot bypass (3) from the pilot jet (5).

**Needle and needle jet**

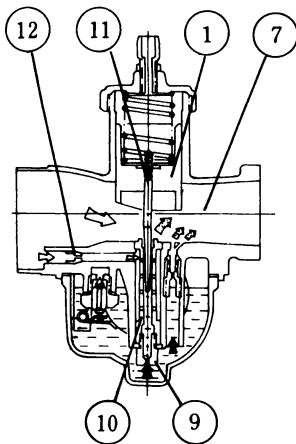
The throttle valve carries a tapered needle which enters a drilled jet known as the needle jet. Normally, this is mounted directly above the main jet and opens into the throat of the carburettor. As the throttle is opened beyond the  $\frac{1}{4}$  open position, the needle and needle jet come into effect, and as the throttle valve rises to allow more air to pass through the carburettor, progressively less restriction is offered to the fuel drawn up from the main jet. The tapered profile of the needle ultimately presents no appreciable restriction in the needle jet, and at this stage, about  $\frac{3}{4}$  throttle, the main jet size becomes the controlling factor.

Adjustment of the needle and needle jet's effect on the carburation is obtained by employing various taper profiles on the needle and choosing one of a small range of needle jet types. This gives a coarse adjustment, which rarely requires any modification once selected by the manufacturer. Fine adjustment for tuning purposes is available by altering the height of the needle in relation to the throttle valve. This is accomplished by moving a clip on the fixed end of the needle to raise or lower the needle, thus altering its range of operation. Raising the needle richens the mixture, whilst lowering it has the opposite effect.



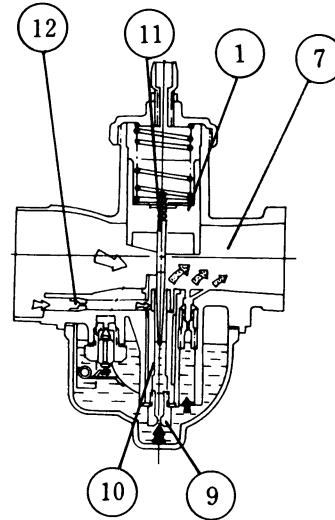
**Fig. 3.7 Typical needle/needle jet arrangement**

- |                                |                  |
|--------------------------------|------------------|
| 1 Air bleed, or emulsion, tube | 4 Throttle valve |
| 2 Main jet                     | 5 Air jet        |
| 3 Needle jet                   | 6 Needle jet     |



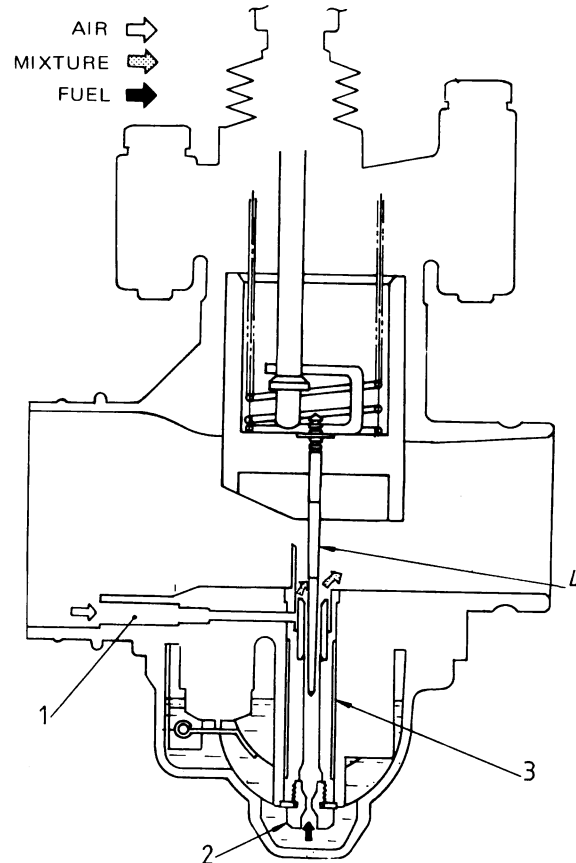
**Fig. 3.8 Needle and needle jet operation – air bleed type**

At  $\frac{1}{4}$  –  $\frac{3}{4}$  throttle, the valve (1) has lifted the jet needle (11) to the point where its taper controls the fuel flowing from the needle jet (10) via the main jet (9). The diagram shows the air bleed type of system in which air from the air jet (12) mixes with fuel in the needle jet/emulsion tube. The resulting mixture is discharged into the main bore (7). The air bleed system is normally favoured for four-stroke use.



**Fig. 3.9 Needle and needle jet operation – primary type**

This diagram is similar to that shown in Fig. 3.8, but lacks the emulsion-forming bleed holes in the needle jet (10). In this instance, the air and fuel droplets are mixed as they enter the main bore. The primary system is applied to most two-stroke carburettors.



**Fig. 3.10 Needle and needle jet operation**

At about  $\frac{3}{4}$  throttle, the restriction offered by the needle (4) and needle jet (3) becomes equal to that of the main jet (2). This marks the transition to main jet operation.

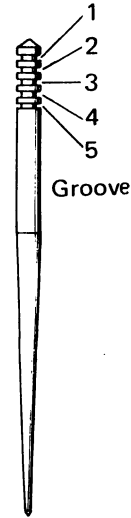


Fig. 3.11 Needle position grooves and profile

The needle is fitted with up to five grooves at its upper end for fine mixture adjustment. The choice of taper governs the overall effect of the needle.

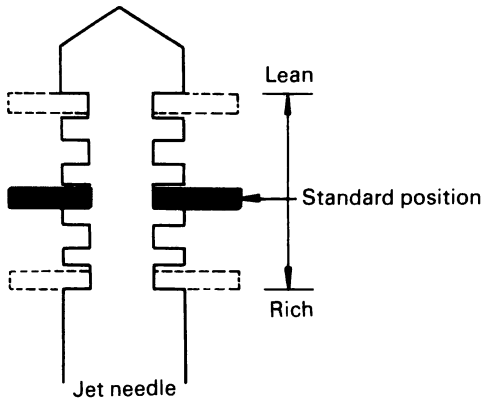
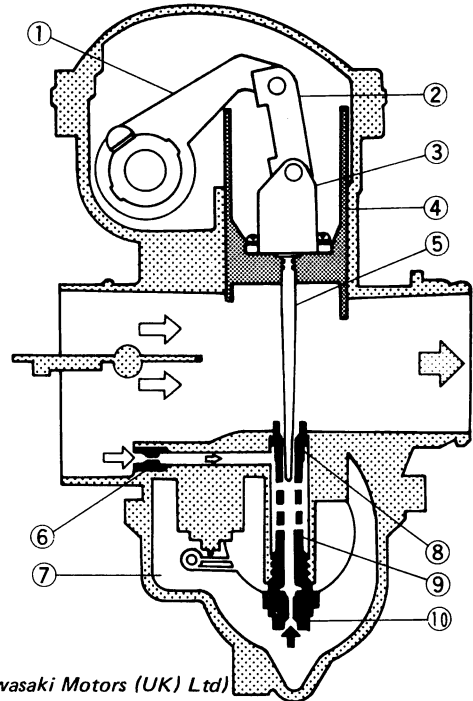


Fig. 3.12 Needle positions

**Main jet**

The main jet represents the final controlling factor in the throttle range, providing a fixed maximum rate of flow. It comes into operation for the final stages of the range, from  $\frac{3}{4}$  to full throttle. The carburettor manufacturer supplies a wide range of precisely drilled jets, and when tuning a carburettor, the main jet size represents the first stage. Once a particular size of main jet has been selected and specified, it is rarely necessary to depart significantly from the original fitment. The exceptions to this are when an engine has been modified internally or the exhaust and/or air cleaner arrangements altered, or where the machine is used consistently above about 3000 feet above sea level.

As mentioned previously, the four divisions listed above are somewhat arbitrary, and in fact the stages overlap considerably. It is helpful nevertheless, to think of the operation of the carburettor in these terms when tuning the instrument.



(Courtesy Kawasaki Motors (UK) Ltd)

Fig. 3.13 Main jet operation

At  $\frac{3}{4}$  to full throttle, engine speed and mixture strength are controlled solely by the throttle valve position and main jet size. Instrument shown is of the rocker-arm type in which the reciprocating movement of the valve is converted to rotary motion for ease of operation.

- |                          |                 |
|--------------------------|-----------------|
| 1 Throttle arm           | 6 Main air jet  |
| 2 Link                   | 7 Float chamber |
| 3 Throttle valve bracket | 8 Needle jet    |
| 4 Throttle valve         | 9 Bleed pipe    |
| 5 Jet needle             | 10 Main jet     |

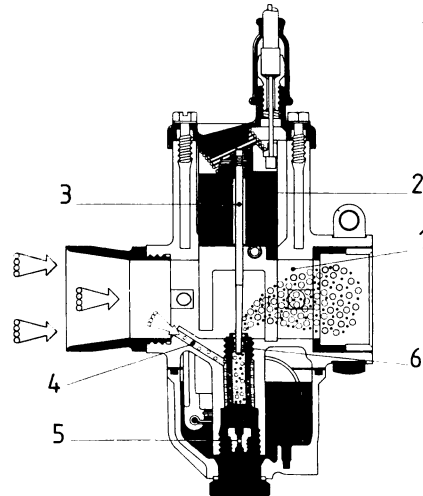


Fig. 3.14 Main jet operation – Dellorto VHB

Note that on some VHB types an air bleed arrangement is employed, and is still operating at full throttle settings.

- |                  |                     |
|------------------|---------------------|
| 1 Main bore      | 4 Air passage       |
| 2 Throttle valve | 5 Main jet          |
| 3 Jet needle     | 6 Needle jet holder |

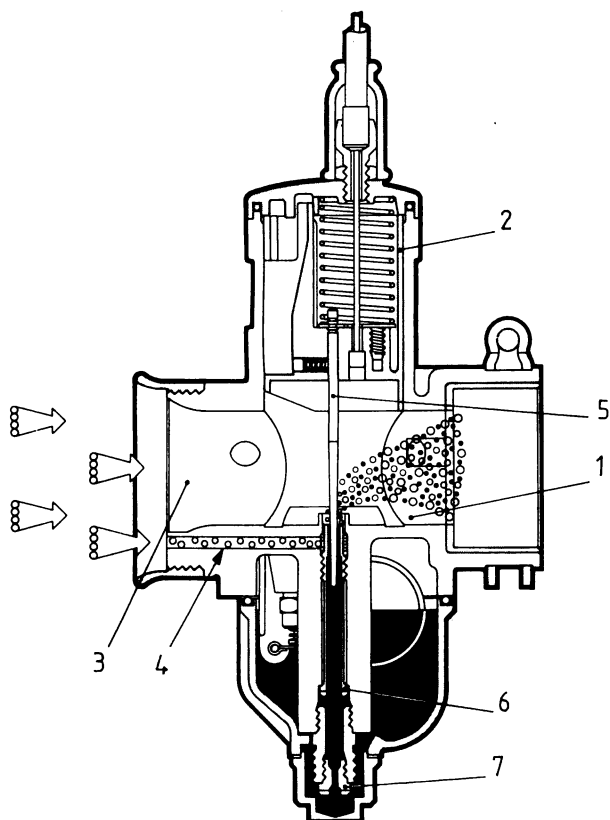


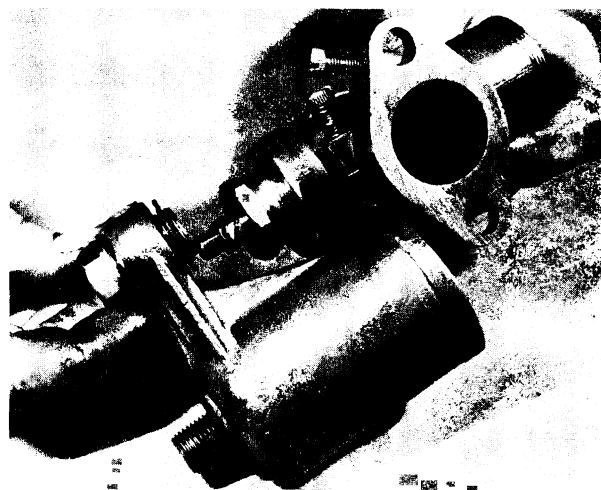
Fig. 3.15 Main jet operation – Dellorto PHB

- |                     |              |
|---------------------|--------------|
| 1 Main bore         | 5 Jet needle |
| 2 Throttle valve    | 6 Needle jet |
| 3 Air entering bore | 7 Main jet   |
| 4 Air passage       |              |

On the engine side of the throttle valve was a pilot outlet which was supplied with petrol via the pilot feed hole in the jet block and air from a small by-pass drilling in the jet block. The air supply was regulated by a tapered pilot air screw, providing pilot mixture adjustment. No separate pilot jet was employed; a carefully sized drilling provided a pre-selected and fixed setting.

The long, tapered jet needle was retained by a clip to the throttle valve, its position being adjustable by means of a range of grooves at the fixed end. The brass needle jet screwed into the underside of the jet block, and was itself threaded internally at the lower end to accept the main jet.

The float chamber was remote from the main body of the instrument, being secured to it by a banjo union which provided the petrol feed to the underside of the jet block. The float was a cylindrical soldered brass construction, carrying the float valve, in the form of a long needle, through its centre. The chamber was closed by a threaded cap incorporating a tickler to provide a means of flooding to assist cold starting, and a small locking bolt to prevent the cap from loosening under vibration.



3.1 The Amal Standard had a separate float chamber retained by a banjo bolt

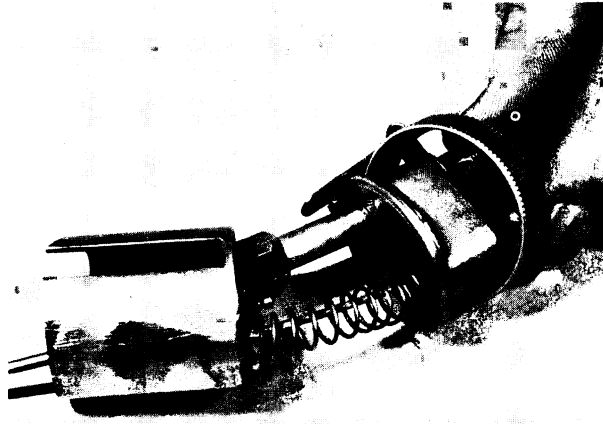
### 3 The development of the slide carburettor

To trace the ancestry of the current slide carburettor, it is convenient to use as an example the various Amal instruments. There are a number of reasons for this choice, but most importantly Amal were at the very forefront of carburettor manufacture during the years that the most important innovations were made, and thus their range typifies this evolution.

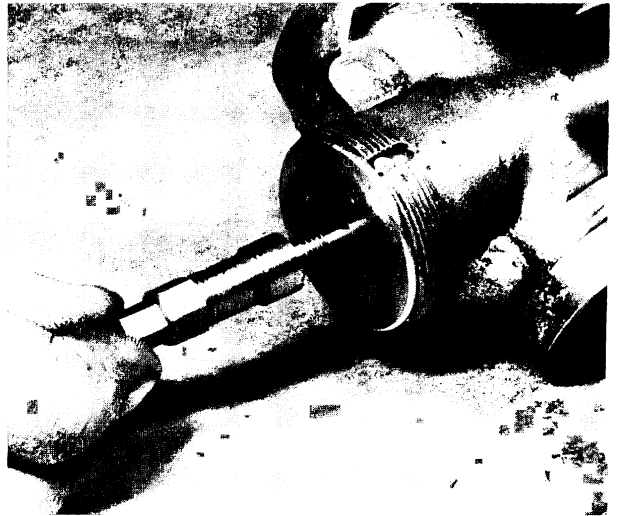
Until the mid-1950s the Amal Standard instrument, and its racing counterparts, reigned supreme, and was fitted as original equipment to most British and many overseas machines. The main body, or mixing chamber, of the instrument was a light alloy casting comprising a main bore, terminating in a two-hole flange fitting for attachment to the inlet stub of the engine. At right angles to this was an extension which carried the throttle valve assembly, resulting in a tubular cruciform shape. Concentric with the vertical, throttle valve, bore, was a cylindrical jet block which formed the mounting point for the needle jet and main jet, and provided a guide for the brass throttle valve. The top of the mixing chamber was closed by a circular cap, incorporating adjusters for the throttle cable and air valve cable, and secured by a knurled ring. The lower end of this bore terminated in a large union nut and tubular holding bolt which between them formed a small well of fluid into which the main jet projected, and the means of attaching the separate float chamber assembly.



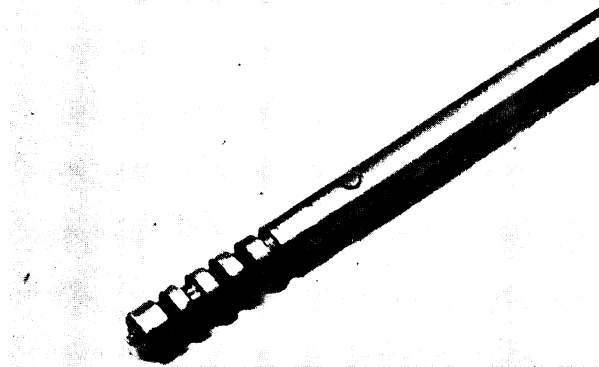
3.2 A removable jet block was fitted inside the main body



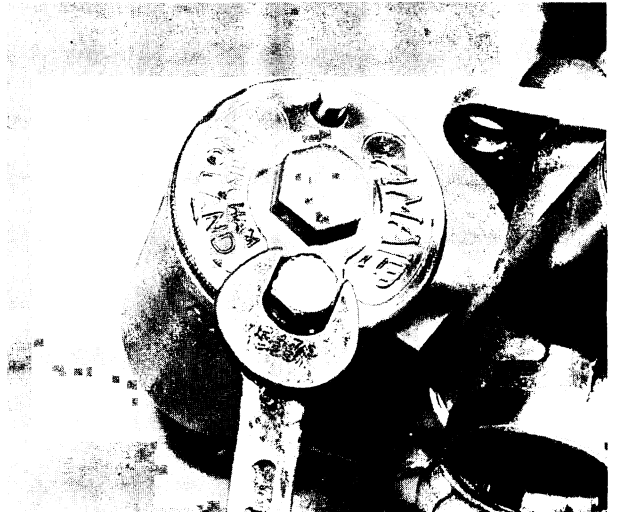
3.3 Mixing chamber top, lock ring and throttle valve assembly are removed as shown



3.4 Main jet projects from underside of body as shown



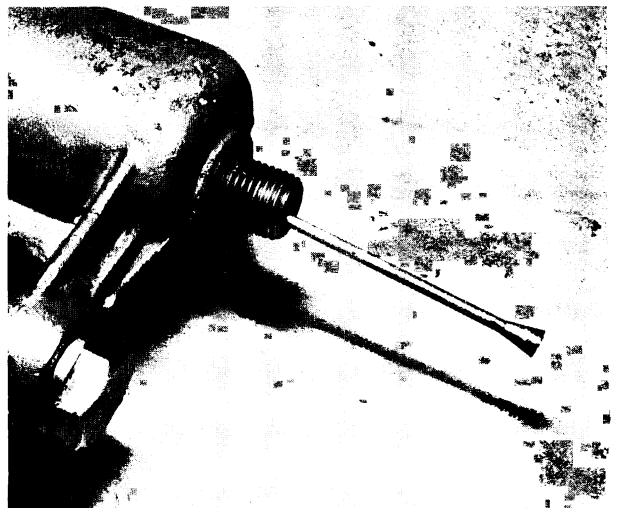
3.5 Jet needle remains similar even today



3.6 Float chamber cap was locked by a small bolt

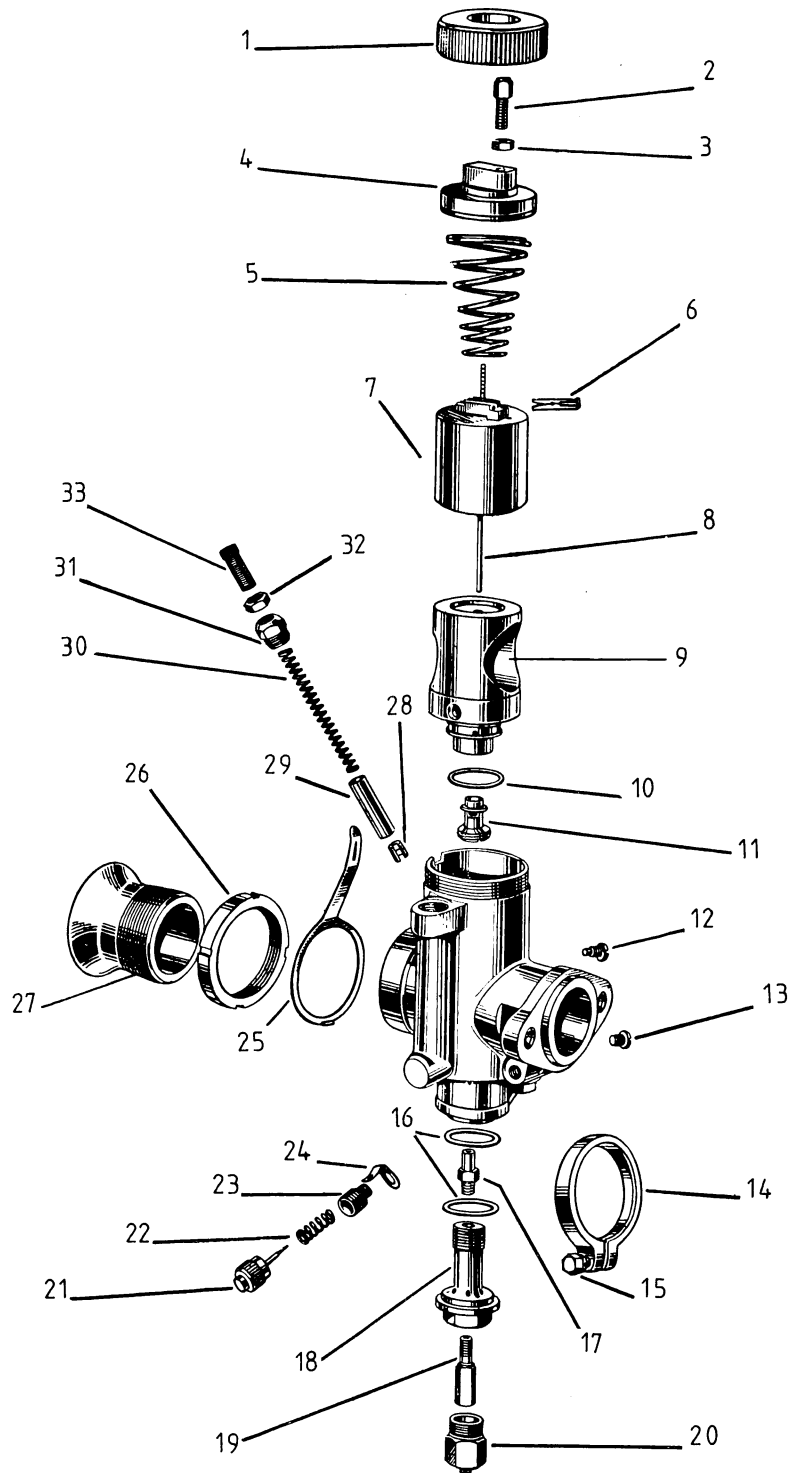


3.7 The cylindrical float was clipped to float needle valve



3.8 The needle valve could be removed from underside of float chamber





**Fig. 3.16 The Amal TT9 Mixing chamber**

- |   |                         |    |                        |    |                     |    |                 |
|---|-------------------------|----|------------------------|----|---------------------|----|-----------------|
| 1 | Mixing chamber cap      | 10 | Seal                   | 18 | Jet holder          | 26 | Lock ring       |
| 2 | Throttle cable adjuster | 11 | Jet choke tube         | 19 | Main jet            | 27 | Air intake tube |
| 3 | Locknut                 | 12 | Adaptor locating screw | 20 | Plug screw          | 28 | Nipple holder   |
| 4 | Mixing chamber top      | 13 | Plug screw             | 21 | Pilot needle        | 29 | Air valve       |
| 5 | Return spring           | 14 | Outlet clip            | 22 | Friction spring     | 30 | Spring          |
| 6 | Needle clip             | 15 | Screw                  | 23 | Pilot needle insert | 31 | Air barrel top  |
| 7 | Throttle valve          | 16 | Seals                  | 24 | Spring catch        | 32 | Locknut         |
| 8 | Jet needle              | 17 | Needle jet             | 25 | Lock spring         | 33 | Adjuster        |
| 9 | Choke adaptor           |    |                        |    |                     |    |                 |

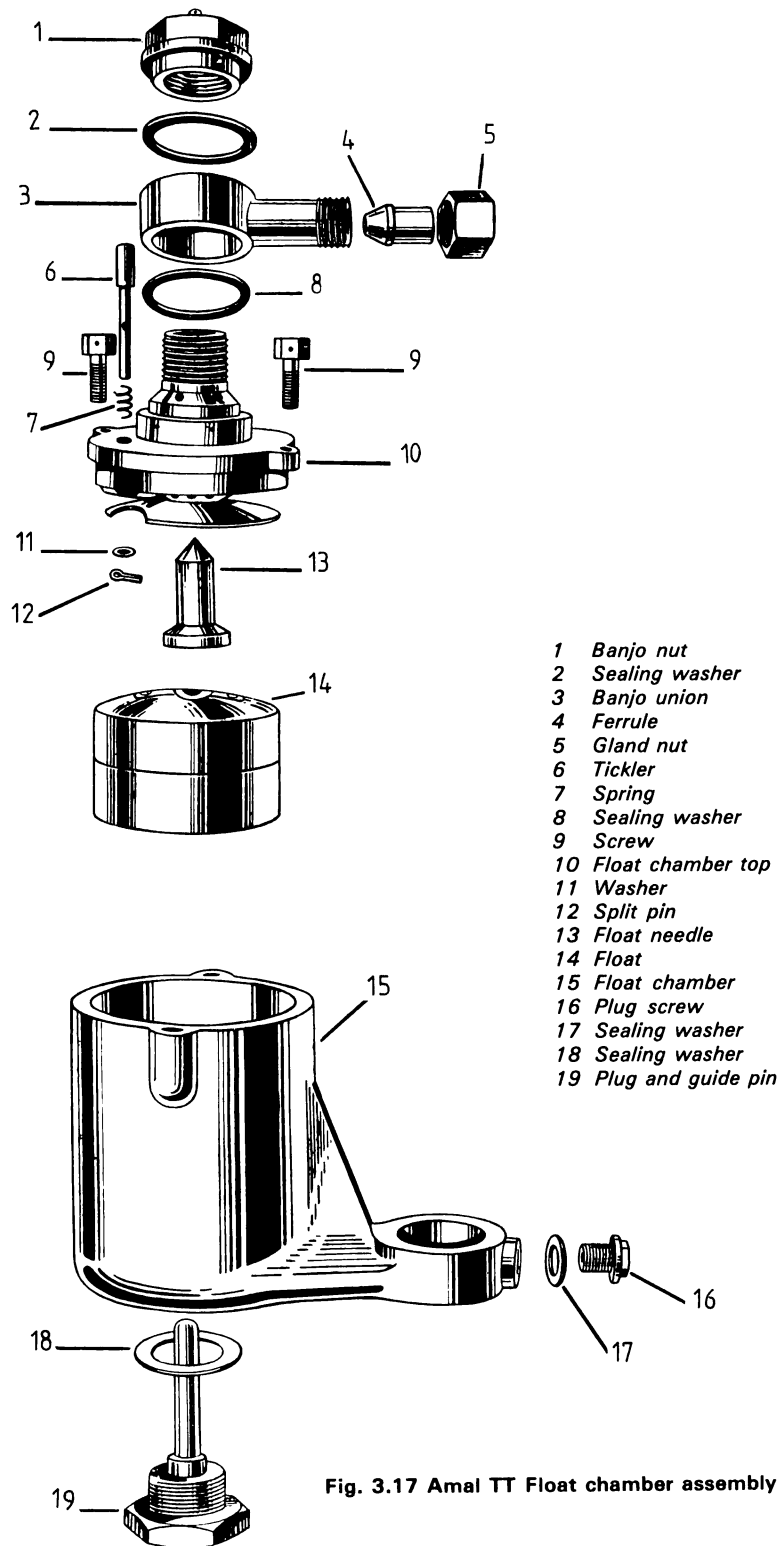
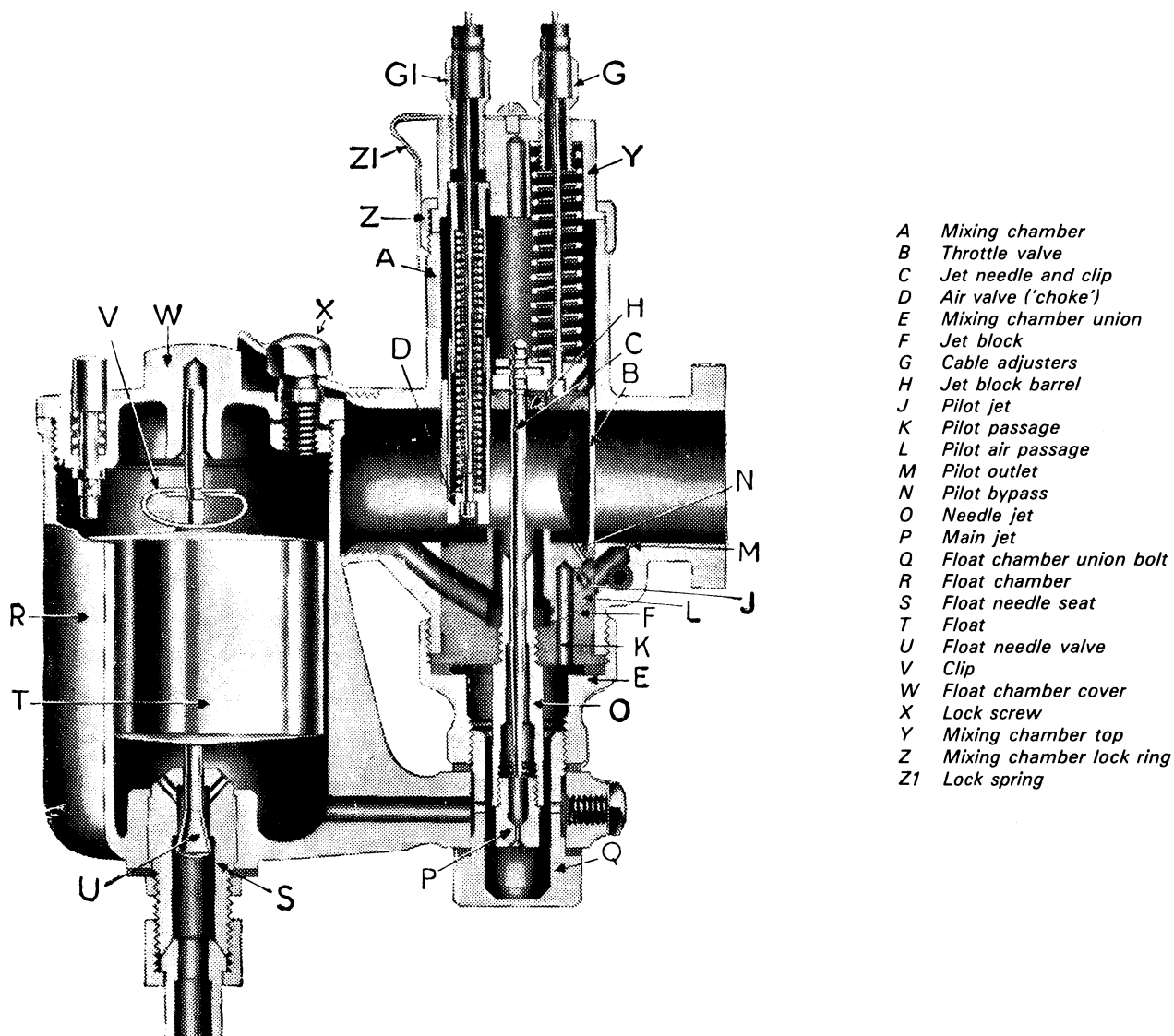


Fig. 3.17 Amal TT Float chamber assembly



**Fig. 3.18** The Amal 289 'Standard' carburettor

*This Amal instrument proved popular for many years, and was standard equipment on the majority of machines of that era. Note the similarities between it and the TT9 racing carburettor.*

Cold starting was catered for by a guillotine-type air slide running just off centre through the throttle valve and positioned by an internal tubular guide.

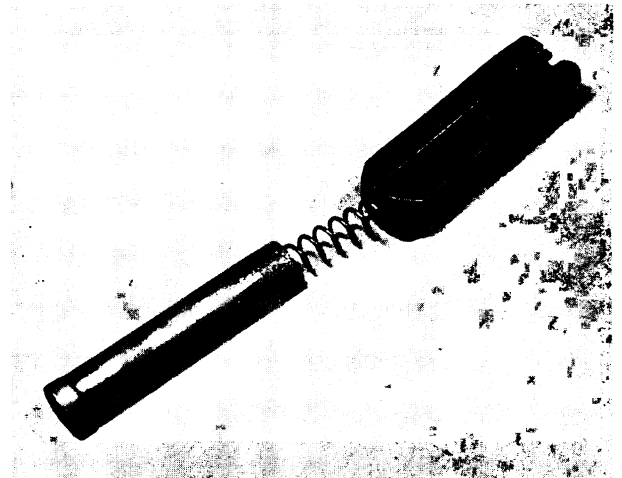
The instrument was very successful, and spawned a number of competition derivatives, thus covering both road and racing applications for many years. The competition instruments were of very similar design, the TT version having an air slide mounted to one side of the main bore, making the latter cleaner internally. The GP models went one stage further by mounting the needle and needle valve remotely, leaving the main bore completely unobstructed. The Type 27 was the forerunner of the TT instrument, but was designed for alcohol fuels only, having no needle jet arrangement and sporting twin float chambers.

Although successful and popular for many years, these instruments were not without their problems. The type of construction was rather complicated, involving two separate casting and multitudinous machining operations. Not only did this call for unnecessary effort on the part of the manufacturer, it also resulted in a comparatively large and bulky instrument which was heavier than desirable and also prone to leakage due to the numerous joints in its construction. The obvious course of action was to combine the main body and float chamber assemblies into a single unit, as this would give a more compact instrument that was easier to manufacture and less prone to leakage in use. This reasoning led to the introduction of a new instrument during the 1950s. The new carburettor employed a much simplified construction method, featuring a single union

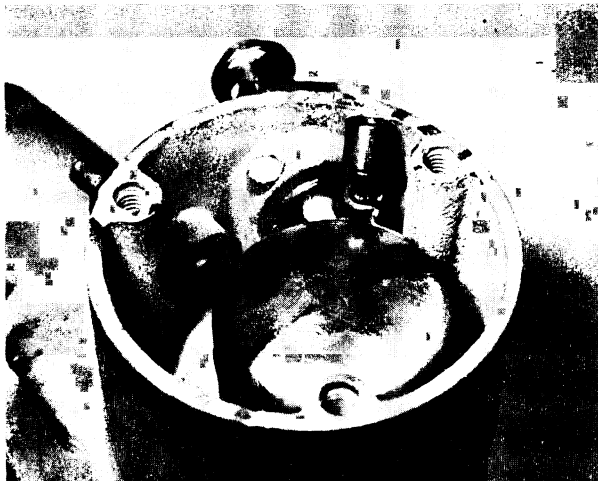
casting for the body and float chamber. Despite its many advantages, the motorcycle fraternity greeted the new instrument with their traditional reserve, and Amal almost dropped the design as a result. Eventually, the Monobloc, as it was known, became accepted and in time inherited the old Standard's cherished reputation for performance and reliability.

The Monobloc instrument provided wide coverage with carburetors of three basic sizes; the 375, 376 and 389. It employed a new float arrangement in which the brass float pivoted on a horizontal pin, acting on a short needle valve mounted above it. The circular float chamber was grafted onto the side of the main body forming part of the single casting used for the complete instrument.

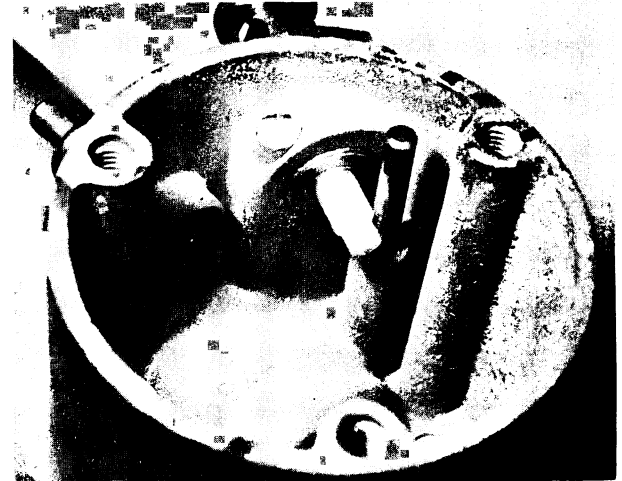
With the new instrument, a removable pilot jet was introduced, affording better tuning versatility in this area. The jet block was secured from the underside by the jet holder, to which was attached the needle jet and, on the underside, the main jet. A cap nut completed the underside of the assembly, and allowed main jet changes to be made very quickly and with minimal dismantling. The small air intakes for the pilot jet spray tube were positioned on the atmospheric side of the main bore, and thus could be protected by the air filter, where this was fitted.



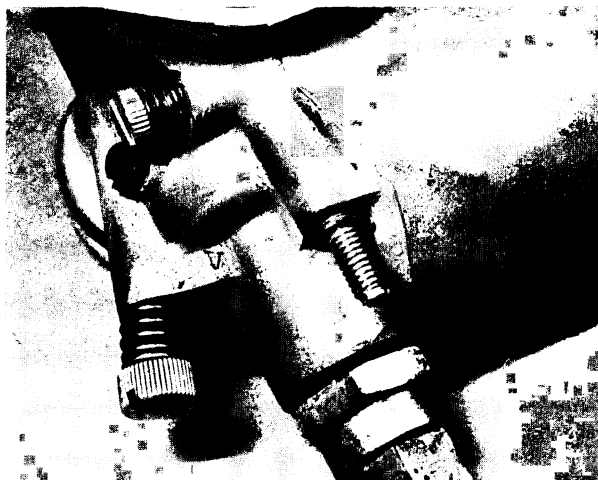
3.9 The air slide, or choke, was used on subsequent carburetors up to the Concentric Mk I



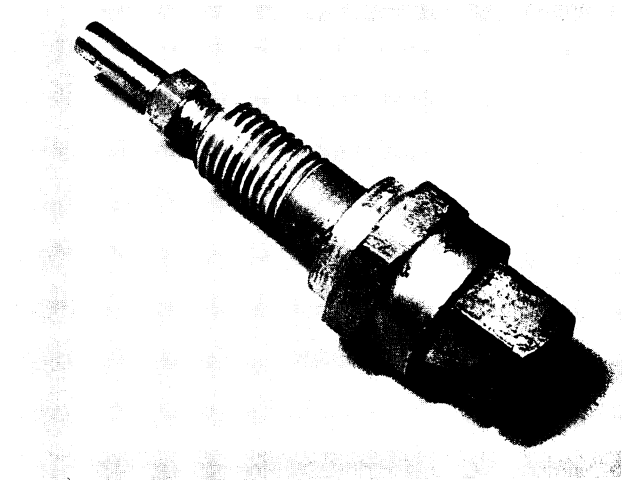
3.10 The Monobloc's horizontally-pivoted float assembly was housed in an integral float chamber



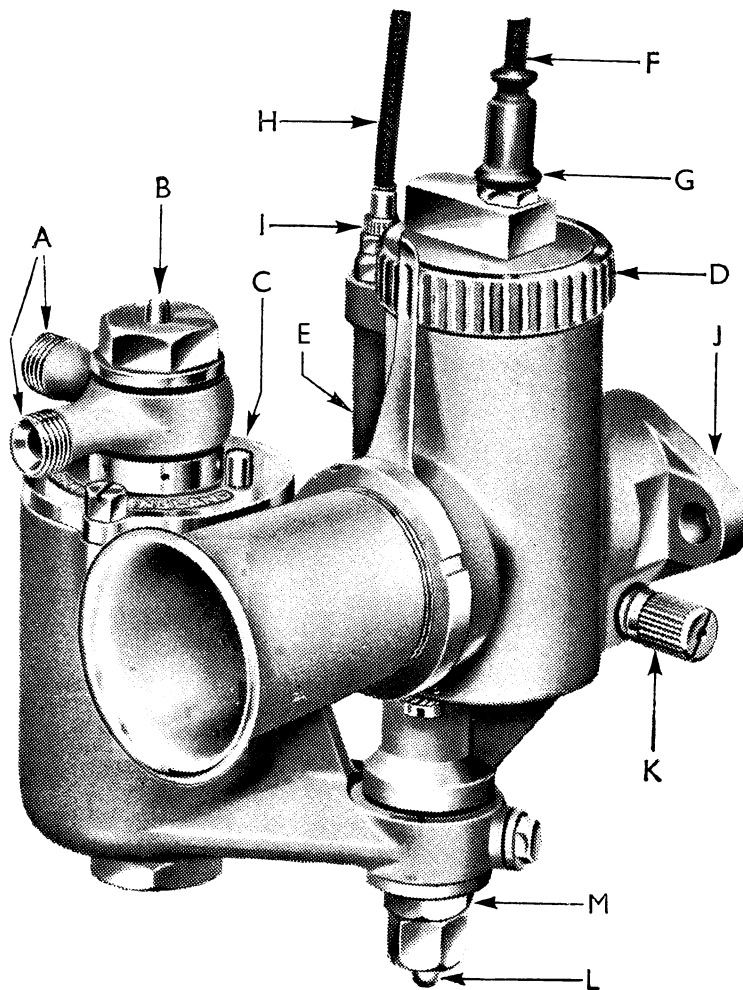
3.11 The new float needle was of the type still used to this day



3.12 A detachable pilot jet was fitted. It was normally covered by a cap nut



3.13 An assembly comprising the needle jet, jet holder, main jet and cap nut was fitted to the bottom of the mixing chamber



**Fig. 3.19** The Amal GP carburettor

- A Twin banjo union*
- B Banjo nut*
- C Tickler*
- D Mixing chamber cap*
- E Locking spring*
- F Throttle cable*
- G Throttle cable adjuster*
- H Air cable*
- I Adjuster*
- J Mounting flange*
- K Pilot adjustment needle*
- L Jet holder plug*
- M Jet holder*

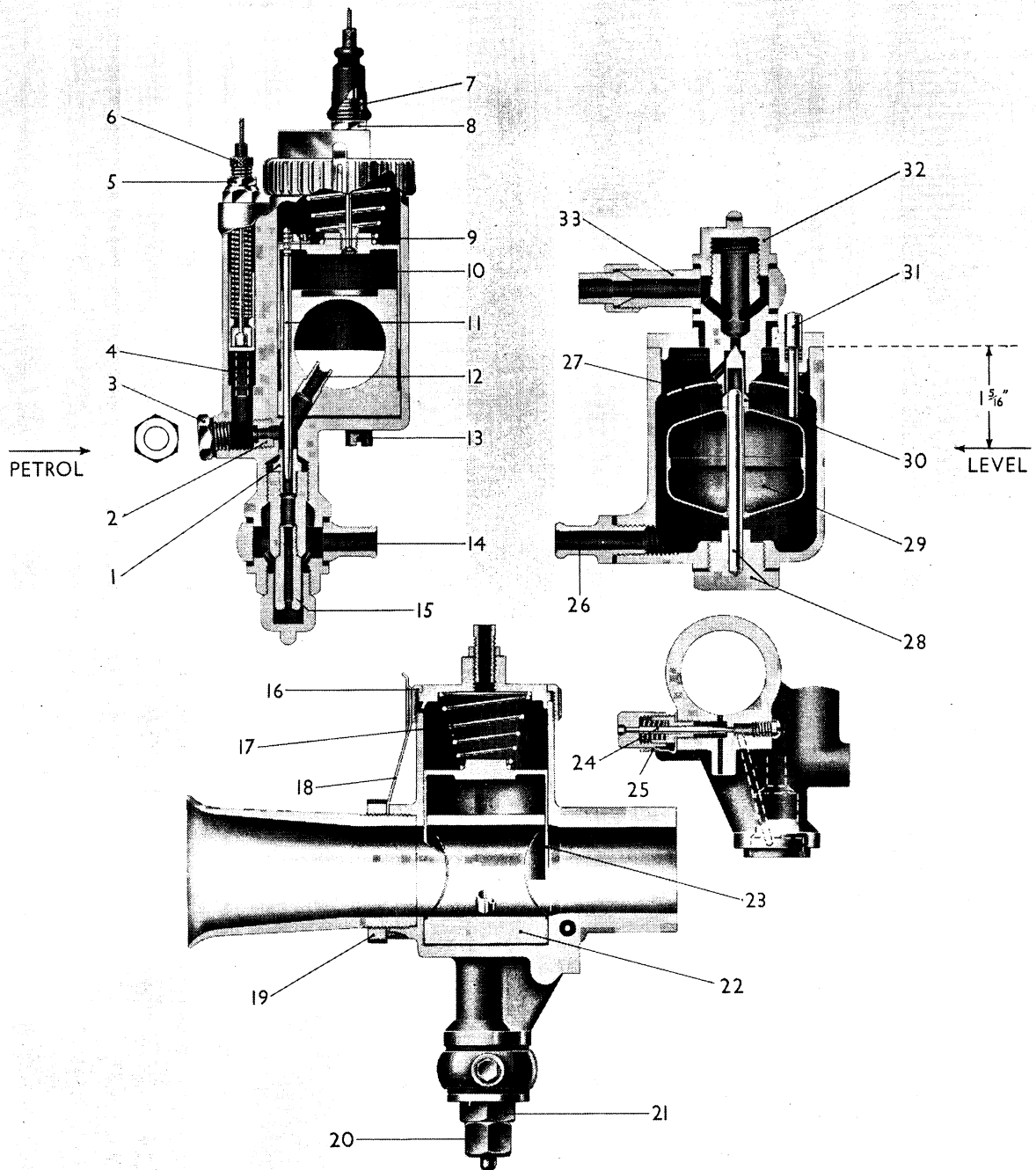
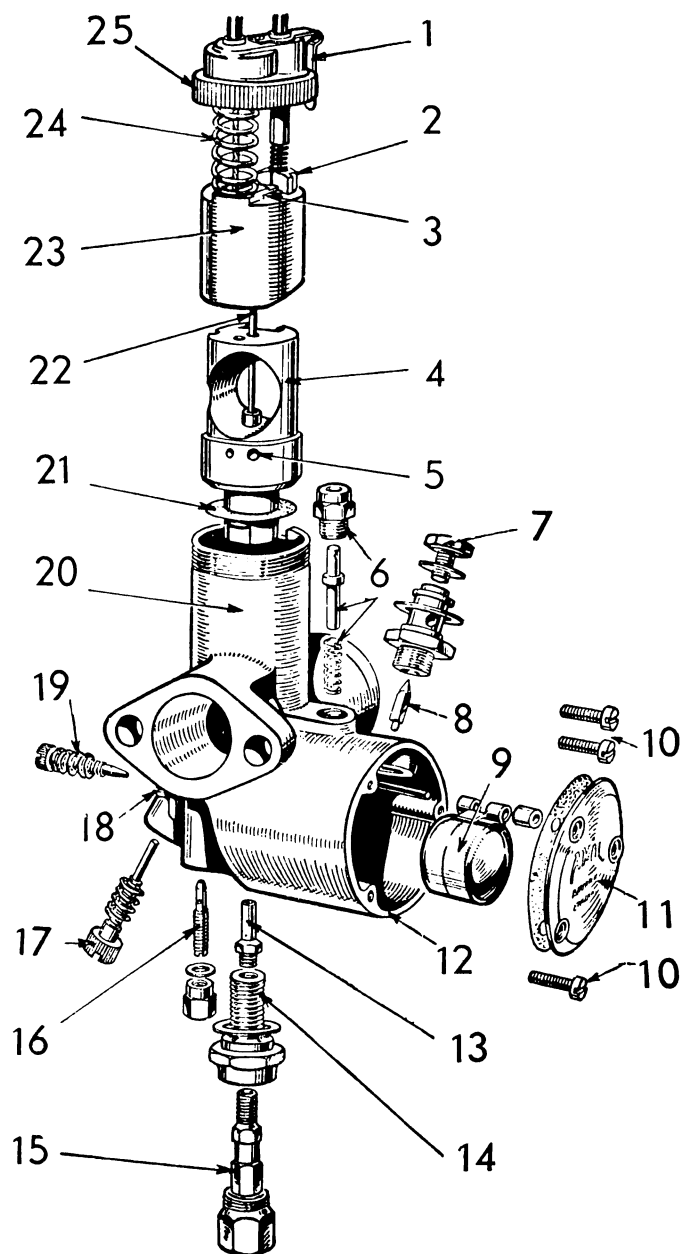


Fig. 3.20 Amal GP carburettor – sectioned view

- |                            |                       |                               |
|----------------------------|-----------------------|-------------------------------|
| 1 Needle jet               | 12 Spring tube        | 23 Throttle valve             |
| 2 Air jet                  | 13 Screws             | 24 Pilot jet adjusting needle |
| 3 Air jet plug             | 14 Banjo union        | 25 Pilot adjuster lock spring |
| 4 Primary air slot         | 15 Main jet           | 26 Petrol outlet connector    |
| 5 Locknut                  | 16 Mixing chamber cap | 27 Baffle plate               |
| 6 Air valve cable adjuster | 17 Return spring      | 28 Base plug and guide rod    |
| 7 Throttle cable adjuster  | 18 Lock spring        | 29 Float                      |
| 8 Locknut                  | 19 Air tube lock ring | 30 Float needle               |
| 9 Needle clip              | 20 Jet plug           | 31 Tickler                    |
| 10 Needle clip screw       | 21 Jet holder         | 32 Banjo nut                  |
| 11 Jet needle              | 22 Choke adaptor      | 33 Banjo union                |



**Fig. 3.21 The Amal Monobloc carburettor**

- |   |                                |    |                     |    |                     |    |                  |
|---|--------------------------------|----|---------------------|----|---------------------|----|------------------|
| 1 | Mixing chamber top lock spring | 7  | Banjo bolt          | 14 | Jet holder          | 20 | Carburettor body |
| 2 | Air valve                      | 8  | Float needle        | 15 | Main jet            | 21 | Fibre washer     |
| 3 | Needle clip                    | 9  | Float               | 16 | Pilot jet           | 22 | Jet needle       |
| 4 | Jet block                      | 10 | Screws              | 17 | Throttle stop screw | 23 | Throttle valve   |
| 5 | Pilot bypass                   | 11 | Float chamber cover | 18 | Locating screw      | 24 | Return spring    |
| 6 | Tickler assembly               | 12 | Float chamber       | 19 | Pilot air screw     | 25 | Lock ring        |
|   |                                | 13 | Needle jet          |    |                     |    |                  |

The new instrument proved very effective in use, and embodied many features of the TT racing types. It rapidly became an almost universal fitment on new road machines, and soon became widely used in most forms of competition, being readily modified to use various fuels. Amal were quick to introduce both left- and right-handed versions, which allowed the carburettors to be mounted close together in pairs for use on vertical twin cylinder engines.

The Monobloc posed few inherent problems in use, but when the time came for redesign, what criticisms had been levelled at it were taken into consideration. Most significant was the tendency for fuel to surge away from the main jet, mainly during hard cornering on sidecar machines. This was inevitable with the float chamber mounted to one side, though less of a problem than with earlier types. The tendency could be reduced by placing the float chamber on the same vertical axis as the main jet, and this would also make for a narrower unit. This last point was of considerable importance as it was difficult to fit a comparatively wide Monobloc unit to vertical engines of more than two cylinders.

These requirements were met by arranging the float chamber around the main jet on the underside of the mixing chamber. The construction method was referred to as concentric, giving its name to the new instrument. This type of construction is almost universal in current slide carburettors. The new 600 and 900 type Concentric carburettors featured a moulded plastics float of annular construction. The main jet, jet holder and needle jet arrangement remained virtually unchanged, but the separate jet block was abandoned in the interests of simplicity. The pilot jet feed passage was now incorporated in the float bowl casting, and the pilot jet, where fitted, was screwed into the underside of the main body. On many models, it was found to be advantageous to locate the pilot jet as near as possible to the pilot outlet, and to accomplish this, the removable pilot jet was relinquished, and a bushed pilot jet pressed into the end of the pilot air screw passage.

It is interesting to note that the Amal carburettor has by now become considerably lighter and is about half the width of the original 'Standard' type from which it was derived. The 600 and 900 types remain about as compact as a slide carburettor can be, mainly due to their simplicity. The original Concentric models have subsequently been renamed the Mk I Concentric, due to the inception of the current square-bodied and bulkier Mk II models; the Series 2600, 2900 and 2000.

The Mk II instruments feature a number of modifications to the earlier types, mainly due to more stringent laws governing

exhaust emission levels. Current instruments must control combustion very efficiently if an illegal level of pollution is to be avoided.

A primary air jet has now been fitted to control the air which pre-atomises the fuel which enters the mixing chamber body. This component rarely requires changing, but can be altered to effect a change in the level of depression acting upon the main jet. The primary air jet is mounted on the atmospheric side of the main body, immediately behind the air intake adaptor.

Cold starting is now effected by a separate cold start circuit providing a richened starting mixture independently of the main instrument. The cold starting circuit can be operated by a carburettor mounted lever or by cable, depending upon the application.

Other detail changes include a one-piece plastic mixing chamber top which screws onto the carburettor body, a flexible, tubular, mounting system in place of the traditional flange mounting and a larger rectangular float bowl retained by four screws. The traditional 'tickler' has now vanished due to legislation controlling the emission of petrol and vapour into the atmosphere. The essential workings of the instrument are largely unchanged, and many of the parts are interchangeable between the Mk I and Mk II versions.

This Chapter has traced the development of Amal instruments from the Standard type to the present-day Concentric Mk II. The important point to note is that this development has been by no means radical. In fact, a Standard type would work almost as efficiently as its modern counterpart. The fact is that by the 1930s the basic format of the slide instrument was well established, and subsequent changes have been by way of refinement rather than radical redesigning. During those fifty years, the carburettor has become smaller, lighter, cheaper to produce, less prone to problems in use and slightly more efficient.

We should not conclude from this that little has been done to improve the carburettor during this period. What is shown is that carburation reached a high level of sophistication compared with that of the average road machine, early on in motorcycling history. Today, we have a wide range of carburettors produced by manufacturers in all parts of the world, to fulfil a wide range of applications. With one or two exceptions, slide carburettors are remarkably alike, and no Mikuni expert would be bewildered by an Amal, for example. This makes life much simpler when it is necessary to tune slide-type instruments, as the procedure is similar irrespective of make.



3.14 The Concentric retained many of the Monobloc's better features, but the float chamber was moved to the underside of the mixing chamber



3.15 Main jet and needle jet now screwed directly into the main body



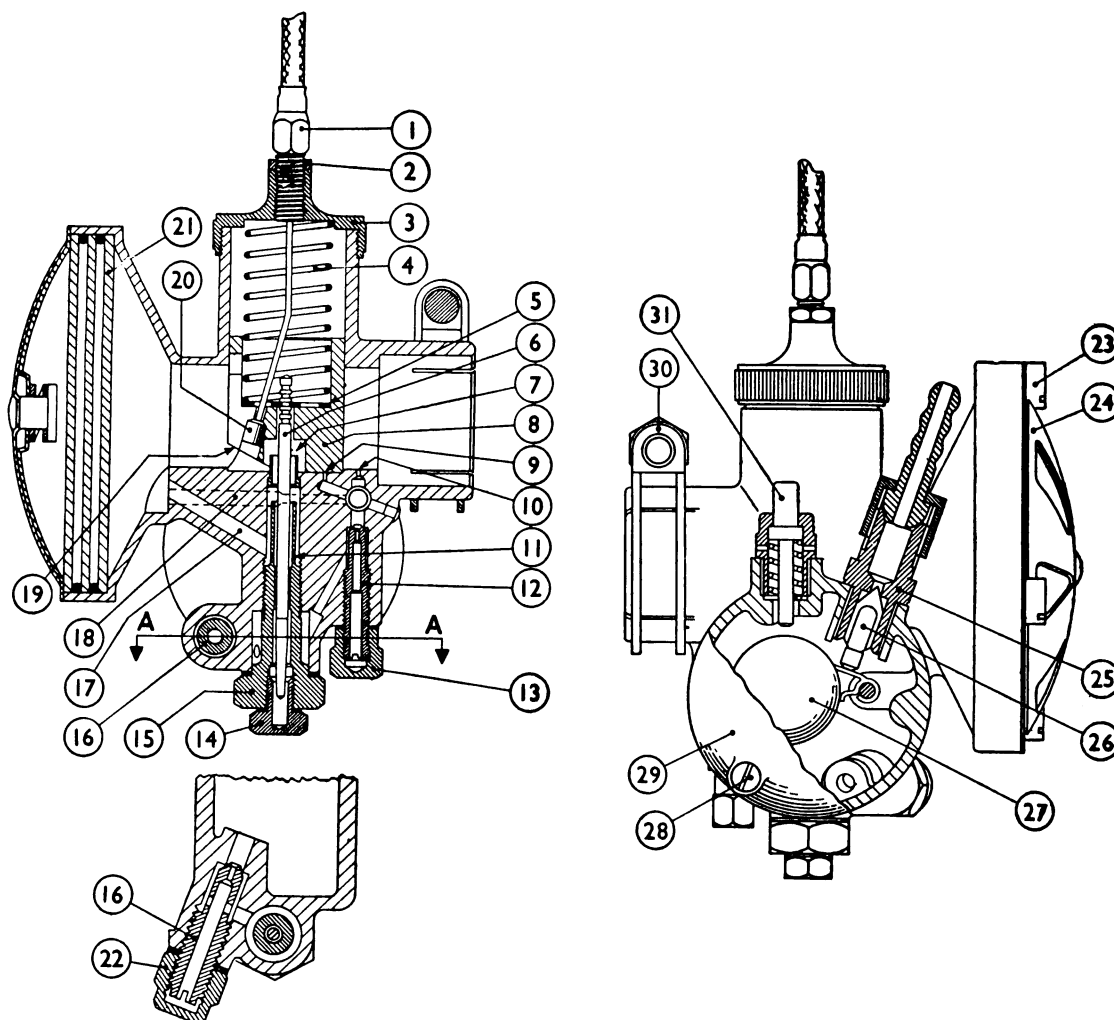
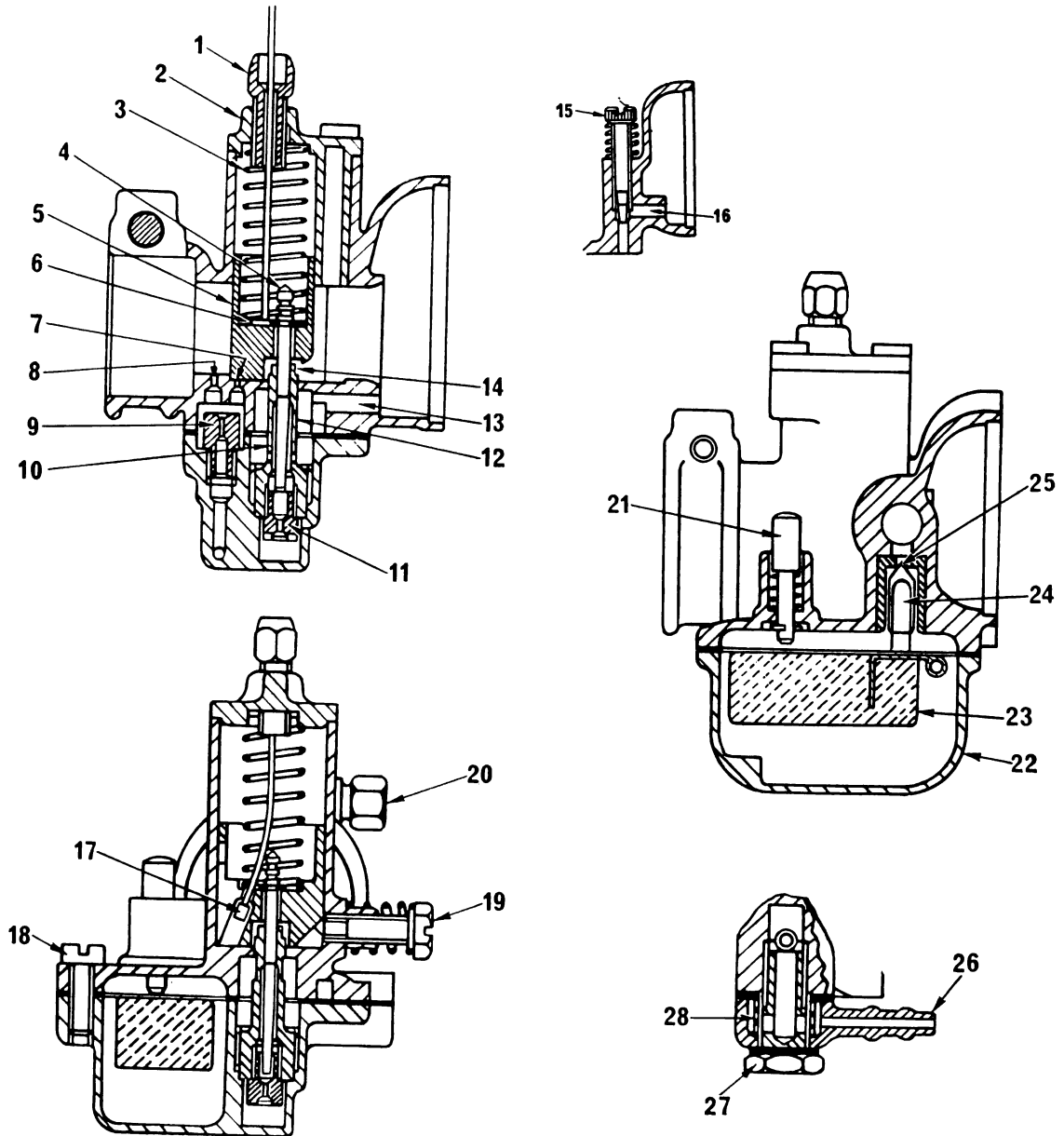


Fig. 3.22 The Amal Monobloc type 363

- |                          |                            |                               |
|--------------------------|----------------------------|-------------------------------|
| 1 Cable adjuster         | 13 Cap nut                 | 24 Strangler                  |
| 2 Locknut                | 14 Plug screw              | 25 Float valve body           |
| 3 Mixing chamber top     | 15 Needle jet              | 26 Float valve                |
| 4 Throttle return spring | 16 Main jet                | 27 Float assembly             |
| 5 Needle clip            | 17 Primary air passage     | 28 Float chamber cover screw  |
| 6 Jet needle             | 18 Pilot air passage       | 29 Float chamber cover        |
| 7 Primary air choke      | 19 Throttle valve cut-away | 30 Fixing clamp               |
| 8 Throttle valve         | 20 Throttle cable nipple   | 31 Tickler                    |
| 9 Pilot bypass           | 21 Air cleaner             | 32 Pilot air screw            |
| 10 Pilot outlet          | 22 Cap nut                 | 33 Throttle stop screw        |
| 11 Bleed holes           | 23 Screw                   | 34 Throttle valve guide screw |
| 12 Pilot jet             |                            |                               |



**Fig. 3.23 The Amal Type 19**

*In this Monobloc derivative, the float assembly has been moved as near as possible to the central axis of the carburettor, pointing the way to the new Concentric types.*

- |                           |                          |                     |
|---------------------------|--------------------------|---------------------|
| 1 Throttle cable adjuster | 11 Main jet              | 20 Mounting clamp   |
| 2 Mixing chamber top      | 12 Bleed holes           | 21 Tickler          |
| 3 Throttle return spring  | 13 Primary air passage   | 22 Float bowl       |
| 4 Jet needle              | 14 Choke tube            | 23 Float assembly   |
| 5 Throttle valve          | 15 Pilot air screw       | 24 Float valve      |
| 6 Needle clip             | 16 Pilot air passage     | 25 Float valve seat |
| 7 Bypass outlet           | 17 Throttle cable nipple | 26 Banjo union      |
| 8 Pilot outlet            | 18 Screw                 | 27 Banjo bolt       |
| 9 Pilot jet               | 19 Throttle stop screw   | 28 Filter           |
| 10 Needle jet             |                          |                     |

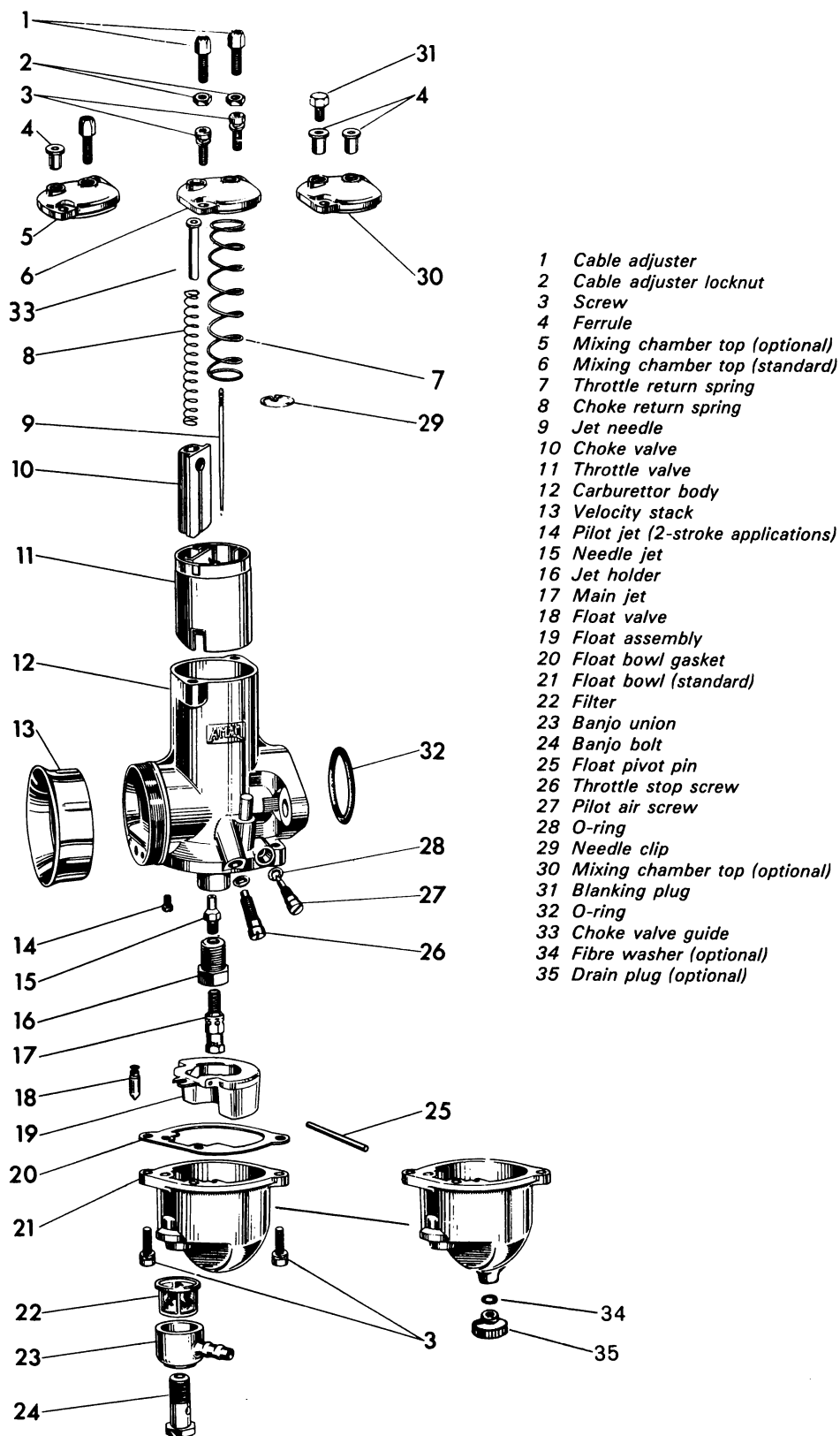


Fig. 3.24 The Amal Concentric Mk I

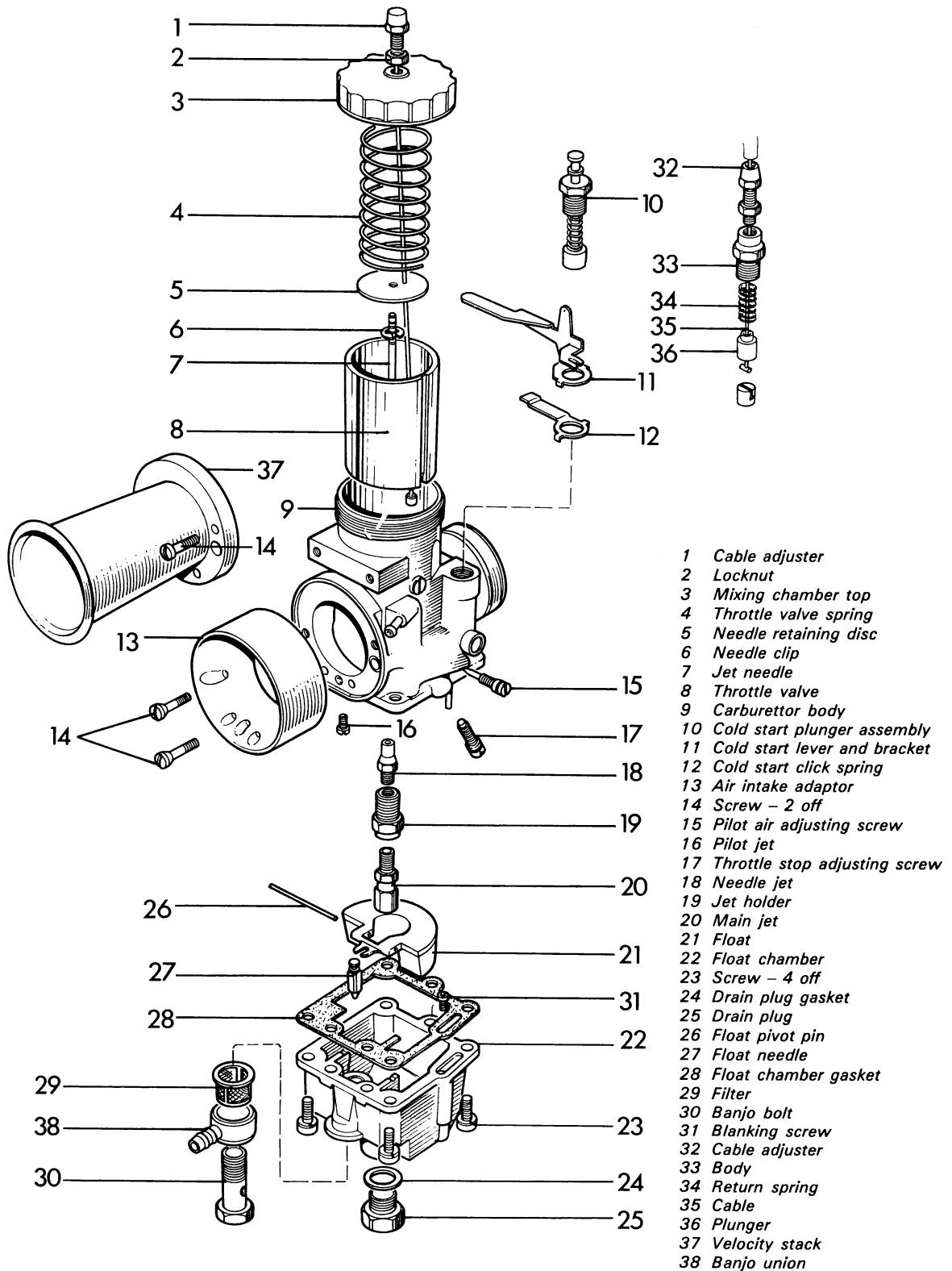


Fig. 3.25 The Amal Concentric Mk II

# Chapter 4 Tuning Slide Carburetors

## Contents

Preliminary checks .....	1
Checking the float height .....	2
Tuning single carburetors – four-stroke .....	3
Tuning twin carburetors .....	4
Tuning multiple carburetors .....	5
Tuning single carburetors – two-stroke .....	6

**1 Preliminary checks**

In this Chapter, a common tuning sequence for all types of carburettor type is given. The method outlined here should be used in conjunction with the chapter relating specifically to the carburettor type in question, as it is there that any peculiarities of the type are discussed and dealt with.

The first phase of carburettor tuning does not relate to the carburettor but to the machine as a whole. Before as much as a screwdriver is directed at the instrument, it is essential to ensure that the rest of the engine is in sound condition. In short, carburettor tuning on a worn engine is unlikely to be successful. All engine adjustments and settings should be attended to, particularly valve clearances on four-stroke engines and ignition timing and contact breaker settings, where applicable, on all engines. Very often, poor performance is blamed on the carburettor when the fault actually lies with the ignition system.

The carburettor should be in good mechanical condition before any attempt at tuning is made. Wear inevitably takes place in components such as the needle and needle jet, and the throttle valve, and very often it is wear in these components which creates running problems, and prompts the owner to try to compensate by adjustment. For further details of the overhaul procedure, refer to Chapter 9.

Where possible, check that the various jet and needle sizes are correct, and that the throttle valve has the right cut-away. This information is normally given in the handbook supplied with the machine, or can be found in a workshop manual. As a last resort, any good dealer for the marque in question should be able to supply the information. In the absence of the basic details of the carburettor's settings, the correct components can be found by trial and error, but only with the expenditure of a considerable amount of time, and a commensurate expenditure on parts.

For most purposes, no special equipment will be necessary, the usual selection of small spanners and screwdrivers being sufficient. On rare occasions the manufacturer may have seen fit to locate a jet in a particularly awkward position, which may call for the use of a thin-walled socket or a box spanner. If this situation arises, exercise patience, and do not try to make do without the correct tool. Jets are usually made of brass, which is easily damaged, as is the rather fragile zinc alloy used for most carburettor body castings.

All single-cylinder and most twin-cylinder machines can be tuned accurately without resorting to expensive test equipment. This is less true of the three- and four-cylinder machines, which

## 2 Checking the float height

The float height setting controls the level of fuel maintained in the float chamber during normal running. If the level varies widely from the specified setting, the resultant rise or fall in fuel level will affect the mixture strength throughout the operating range. If the level is too high, an excessive amount of fuel will be drawn into the engine for a given amount of air, causing the engine to run too rich. Conversely, a low fuel level will starve the fuel supply, leading to weakness.

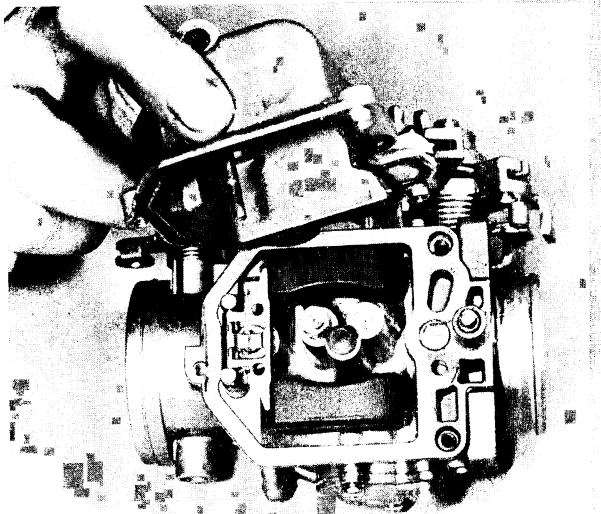
The method of measuring the float height varies widely, and may even differ between similar models using basically similar carburetors. It follows that it will be necessary to refer to a workshop manual or to a helpful dealer to obtain the relevant setting and measuring method.

On many instruments, it will be necessary to remove the float bowl, invert the carburettor body so that the float valve is closed by the weight of the float, and measure the distance between the uppermost edge of the float and the gasket face of the carburettor. On other models, a threaded plug is fitted to the float bowl. This can be removed to allow a transparent tube to be attached whilst the carburettor remains mounted on the engine. The tube is then held next to the float bowl and the petrol supply turned on. As the float bowl fills, the level of fuel will be shown in the tube, and can thus be measured.

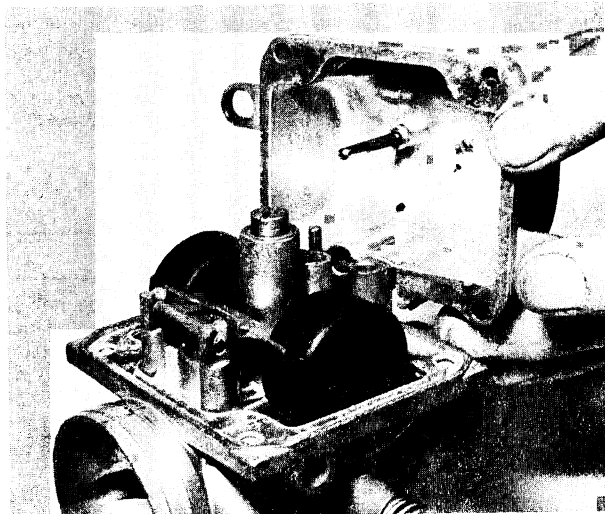
Adjustment is normally made by judicious bending of the metal tang to which the float needle is attached. It should be noted that the smallest movement of the tang will have a pronounced effect on the fuel level, and discretion is called for when making this adjustment. Most manufacturers allow a tolerance of around  $\pm 1.0$  mm or more.

A few carburetors, notably Amal, do not provide any easy means of float height adjustment, and in the case of the latter, check that the needle valve components are unworn. If in good condition, the float level can be assumed to be correct.

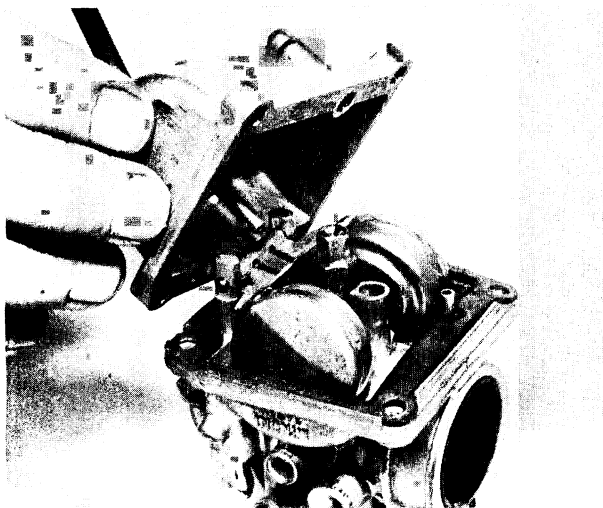
Where more than one instrument is fitted, it is essential to ensure that the level in each float bowl is the same. Any discrepancy here will be in evidence when trying to balance the instruments, and will prove impossible to resolve by adjustment.



4.1 A typical float arrangement. The example shown here is that of the Honda CX 500



4.2 Another common float arrangement (Suzuki X7)



4.3 The Yamaha YB100 employs soldered brass floats

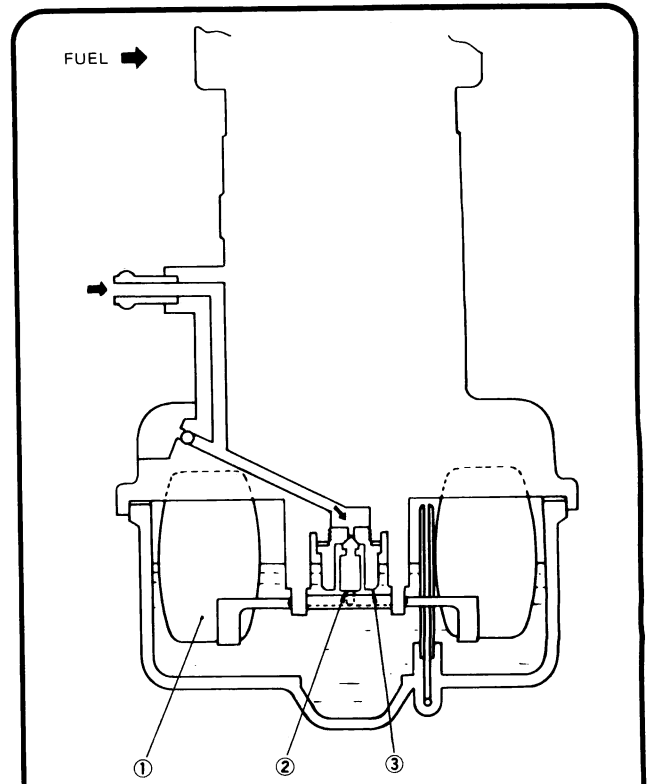


Fig. 4.1 Typical float arrangement

*This type of float system is fitted to the majority of current carburetors (Mikuni VM series shown here).*

- 1 Float assembly
- 2 Float valve
- 3 Float valve seat

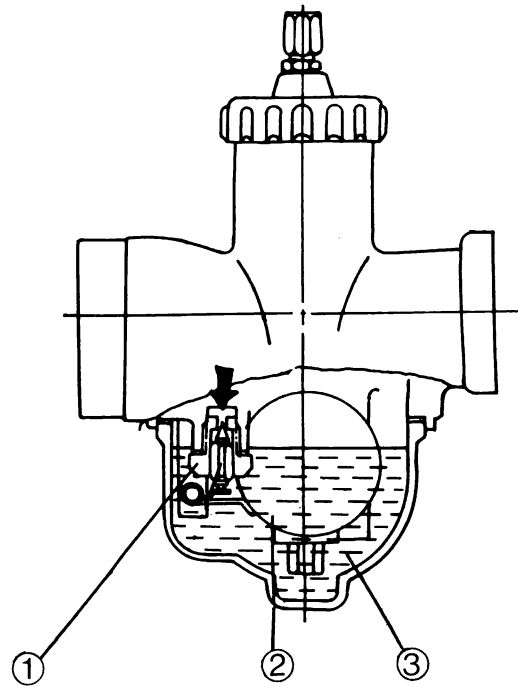
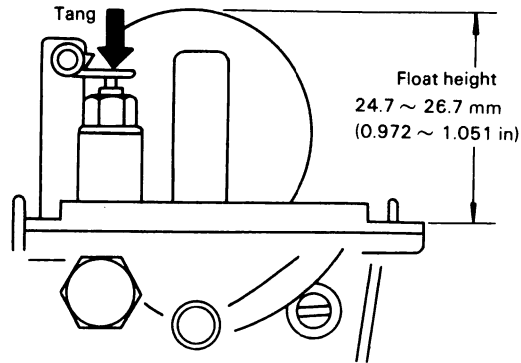


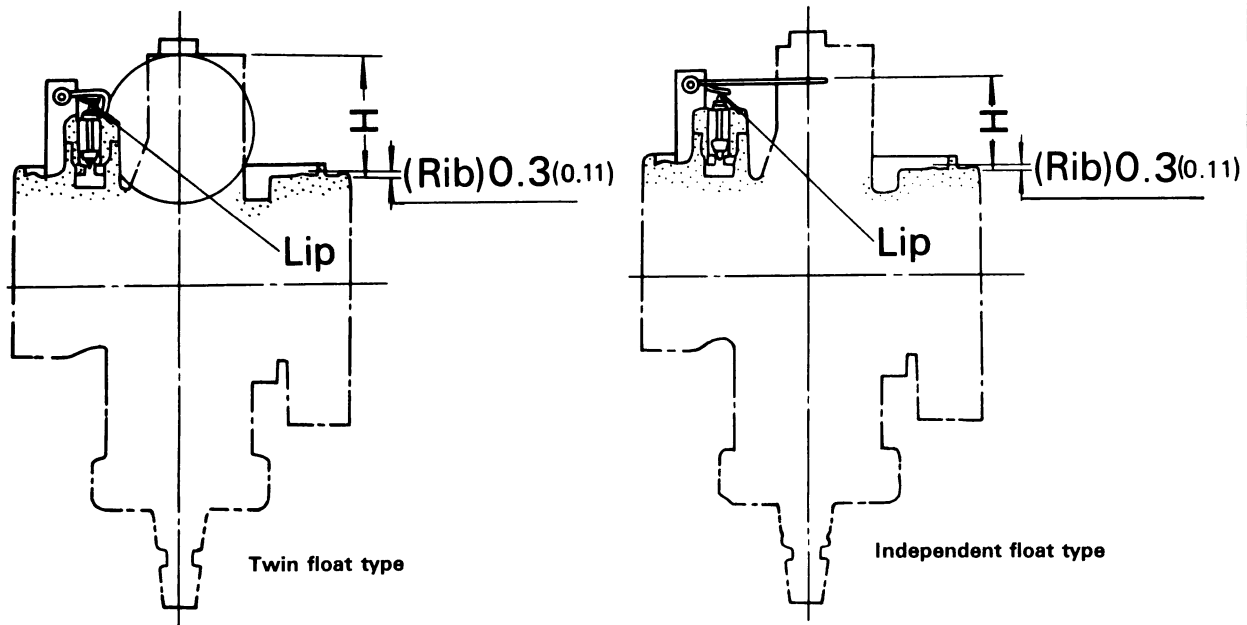
Fig. 4.2 Typical float arrangement (side view)

- 1 Float valve assembly
- 2 Fuel
- 3 Float



**Fig. 4.3** Float height measurement

*On most conventional systems, the float height is measured between the float and the carburettor gasket face, as shown here. Normally the carburettor is inverted for this measurement.*



*The following float settings should be made with the carburettor in the inverted position. These figures are based upon straight and upright mountings.*

*All mountings should be made within 20° of level and straight. Any variance will require a proportional alteration in determining the correct float level.*

**Fig. 4.4** Float height setting – Mikuni twin and independent float types

*The left-hand illustration shows the conventional twin or paired float system, compared with the independent float model on the right. In the case of the latter, measurement is taken between the float lever arm and the gasket face. H indicates the float height, which varies according to model.*

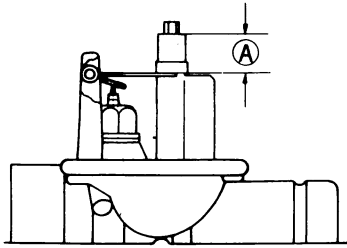


Fig. 4.5 Float height measurement – independent float types

Another method for checking the float lever height on independent float types is shown here. A indicates the distance to be measured between the lever and the main jet holding projection.

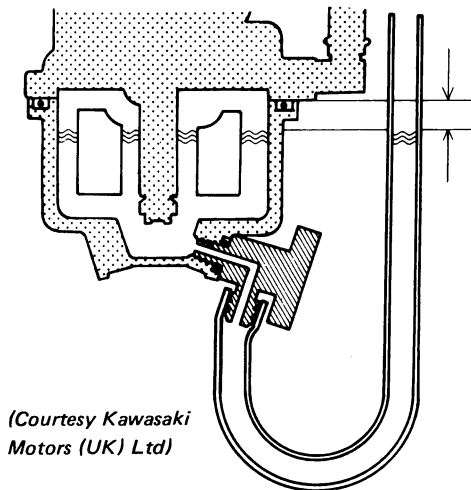


Fig. 4.6 Fuel level measurement

As an alternative to measuring float height, some manufacturers prescribe the measurement of the normal fuel level. This is accomplished by fitting a length of plastic tubing to the drain plug as shown. The fuel level will be visible in the tube.

### 3 Tuning single carburettors – four stroke engines

#### Stage 1: main jet

1 Start the engine, and run the machine until normal operating temperature is reached. Equipped with a sparking plug spanner, select a suitable stretch of road on which the operation of the main jet can be tested. An ideal location would be a clear stretch of country road where normal road hazards are minimised. The object of the test is to run the engine at full throttle, though not necessarily full speed, so that the suitability of the main jet can be assessed. On the larger machines using a single carburettor, this test may involve riding at speeds which may incur the displeasure of the local traffic police. If it is anticipated that this may be the case, the author strongly urges that the test be carried out on a private road or test track and not on the public highway.

2 Run the engine at full throttle for as far as the test road permits. About a quarter of a mile would be ideal. At the end of the test, close the throttle, declutch the engine and switch off the ignition to stop the engine as quickly as possible.

3 Coast to a halt, and then remove the sparking plug(s), taking care to avoid burnt fingers. Examine the plug electrodes carefully, noting the colour of the deposits on them. If all is well with the main jet, the plugs will be an even light tan colour, indicating that mixture strength is correct. If this is the case, the main jet can be assumed to be correct, and attention may be

turned to stage 2 of these tests.

4 A blackened, sooty, appearance is indicative of a fuel-rich mixture, and calls for a smaller main jet size. Repeat the test runs using progressively smaller jets until a healthy plug colour is obtained. A whitish-grey appearance is indicative of overheating and a weak mixture. Again, repeat the tests using progressively larger main jets until the correct plug colour is shown. In practice, a weak mixture is the greater of the two evils, and can lead to serious engine damage if ignored. Burnt valves or holed pistons can result. If in doubt, err on the side of a rich mixture as a safety measure.

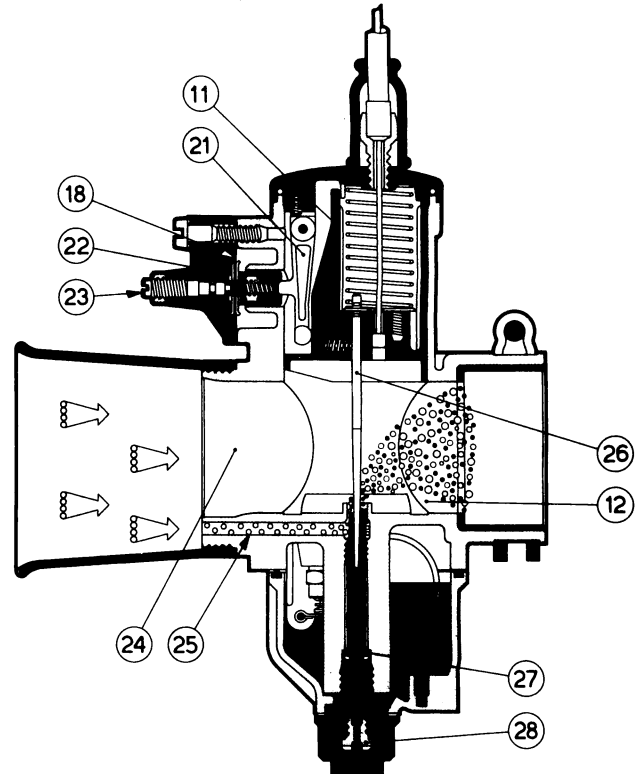


Fig. 4.7 Main jet operation (Dellorto PHM shown)

At  $\frac{3}{4}$  to full throttle openings the idle circuit and needle/needle jet (26) combination will have little noticeable effect. Where an accelerator pump (22) is fitted, as in this example, it will have operated to cover the transition to main jet operation. Air velocity through the main bore (24) is high, a proportion of which is drawn through the primary air passage (25) to aid vaporisation. Fuel is drawn through and metered by the main jet (28), flows through the needle jet (27) and is discharged into the main bore (12).

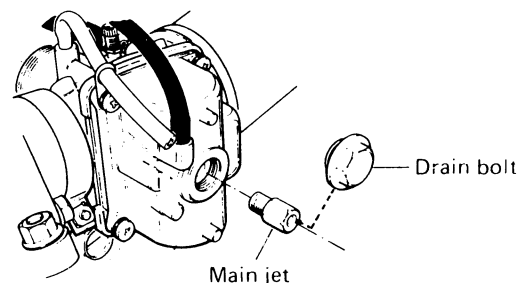
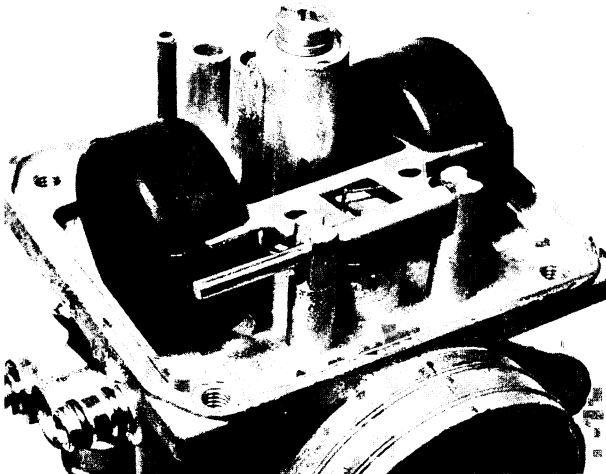


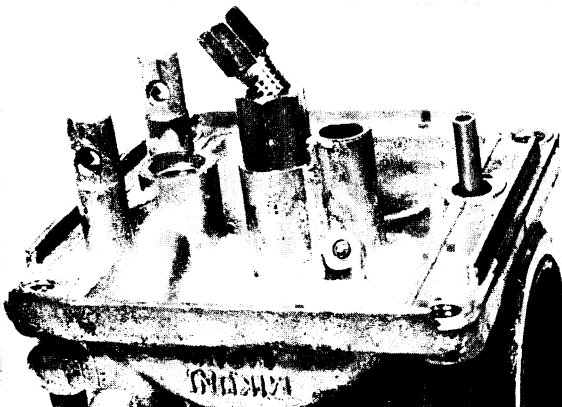
Fig. 4.8 Main jet location

Some carburettors have a large drain plug, permitting quick main jet changes.





4.4 Round headed main jet with screwdriver slot to facilitate removal (Suzuki X7)



4.5 The other common main jet type has a hexagonal brass body (Yamaha YB100)

**Stage 2: pilot circuit**

1 Set the throttle stop screw so that the engine runs at a fast idle, and check that there is ample free play in the throttle cable. If the pilot air screw's nominal setting is known, set it in this position, otherwise screw it fully home and then back it off by about 1½ turns. Start the engine, and slowly unscrew the throttle stop screw until the tickover speed drops to the point where the engine begins to falter.

2 Adjust the pilot air screw by ¼ turn at a time, noting the effect on the engine. If the tickover slows still further, turn the screw in the opposite direction. It will be found that there is a position where the idle speed is at its highest, and moving the setting either side of this position will slow the engine. Having established the optimum setting, unscrew the throttle stop screw once more to slow the idle speed, then repeat the pilot air screw adjustment sequence.

3 The overall sequence should be repeated until a slow, even tickover is obtained. On four-stroke engines, this should prove fairly straight-forward, although it may prove necessary in practice to raise the speed very slightly in the interests of reliability in use. Two-stroke engines are characteristically reluctant to idle reliably, and some compromise often has to be made by raising the throttle stop setting to avoid frequent stall-

ing. If it proves impossible to obtain a reliable setting, and the idle speed varies widely and erratically, suspect either an ignition system fault or a worn carburettor. An instrument with excessive clearance around the throttle valve will allow varying amounts of air to leak past it, especially at tickover, and will prove impossible to adjust correctly.

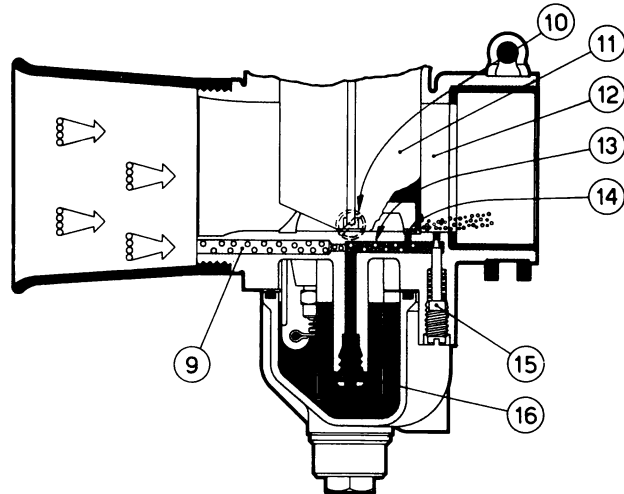


Fig. 4.9 Pilot circuit operation (Dellorto)

At idle speeds, the throttle valve (11) is almost closed, its resting position, and thus idle speed, being controlled by the throttle stop screw (10). Air flowing beneath the valve has a slight effect on the bypass outlet (14) and a small amount of fuel enters the bore by this method. Air drawn along the primary air passage (9) mixes with fuel flowing from the main jet (16). The resulting emulsified mixture exits via the pilot outlet, its flow rate being regulated by the pilot mixture screw (15).

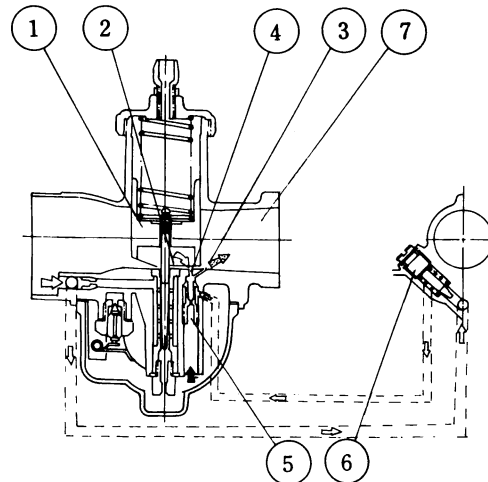


Fig. 4.10 Pilot circuit operation (Mikuni)

Compare the pilot circuit shown here with that described in Fig. 4.9. It will be noted that it is essentially similar in operation, but in the case of Mikuni and many other types a pilot air screw is used instead of a pilot mixture screw. In this system only the air flow in the pilot system is controlled, the fuel being controlled solely by the pilot jet.

- |                          |                   |
|--------------------------|-------------------|
| 1 Throttle valve         | 4 Bypass outlet   |
| 2 Air flow beneath valve | 5 Pilot jet       |
| 3 Pilot outlet           | 6 Pilot air screw |

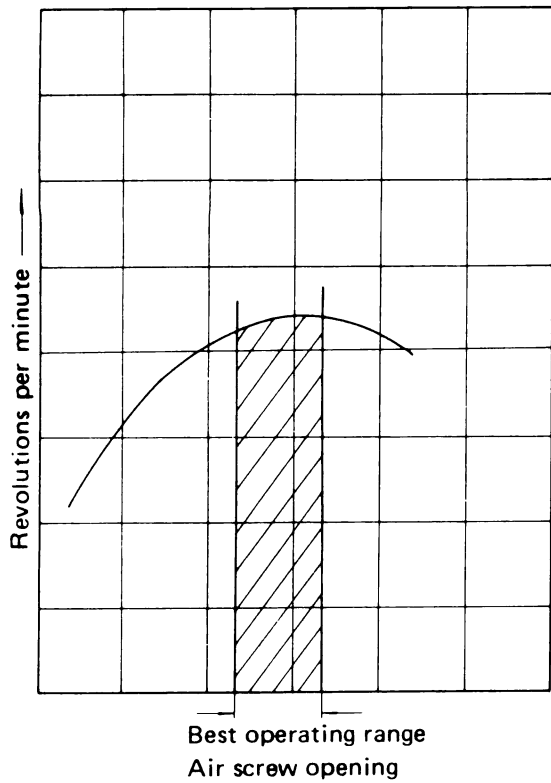


Fig. 4.11 Optimum air screw operating range (typical)

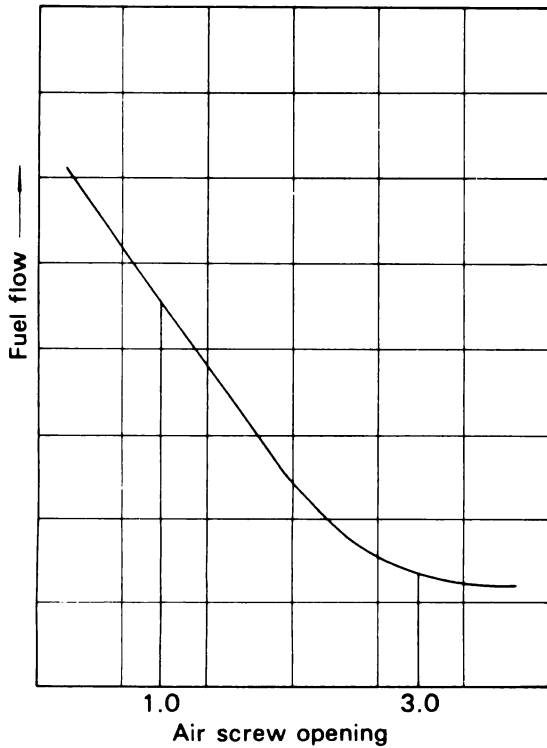
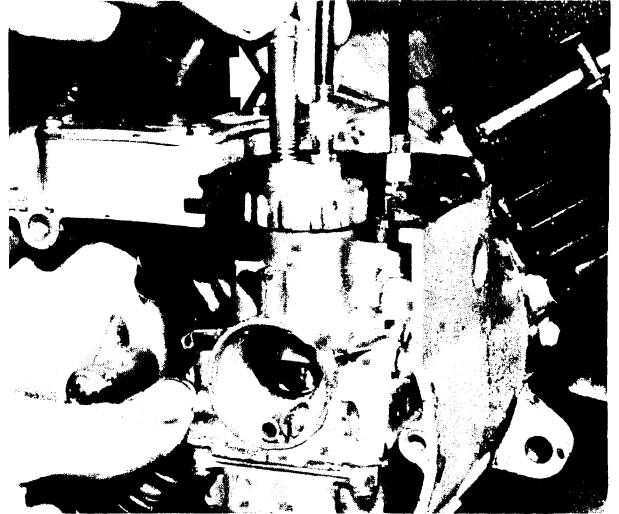
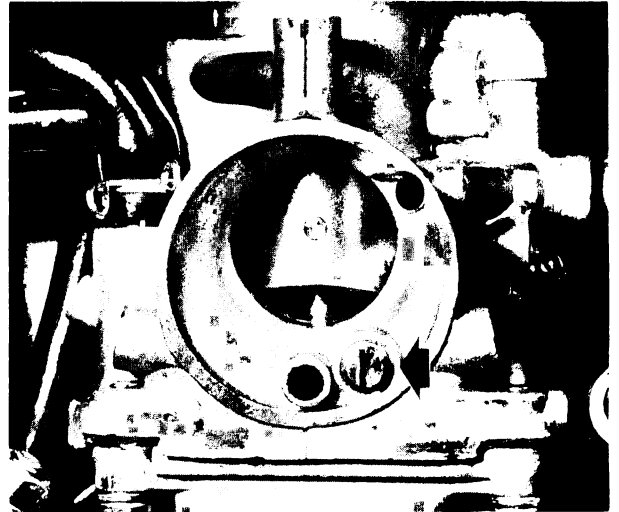


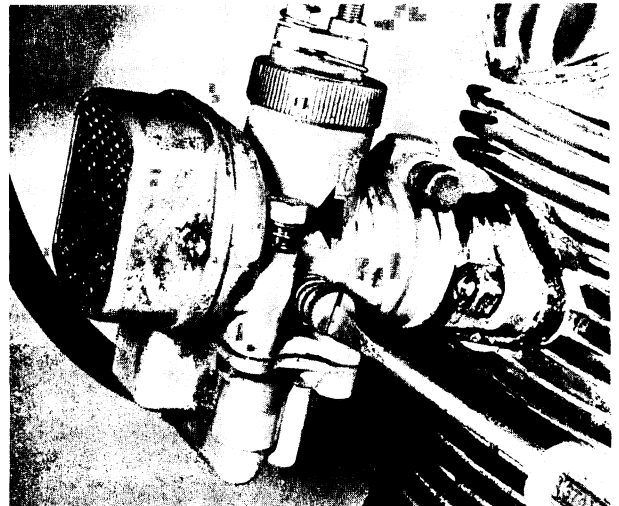
Fig. 4.12 Weakening effect of progressive air screw settings



4.6 Rotary valve induction systems, as on the Yamaha YB100, often necessitate a throttle stop screw which projects from the carburettor top



4.7 An unusual mixture screw location. On the YB100 and similar machines the screw is located at the front of the carburettor



4.8 In the case of this Amal instrument, the throttle stop is at 90° to the body, whilst the mixture screw (arrowed) runs vertically downwards

**Stage 3: throttle valve cut-away**

1 It should be stressed at this point, that it is unusual to find that the throttle valve cut-away is incorrect, assuming that the component fitted corresponds to that originally specified. Needless to say, if the engine has been modified, this may not still hold true. It should be noted that the overlap between the effects of the cut-away and the needle position will necessitate attention to both areas if problems are experienced.

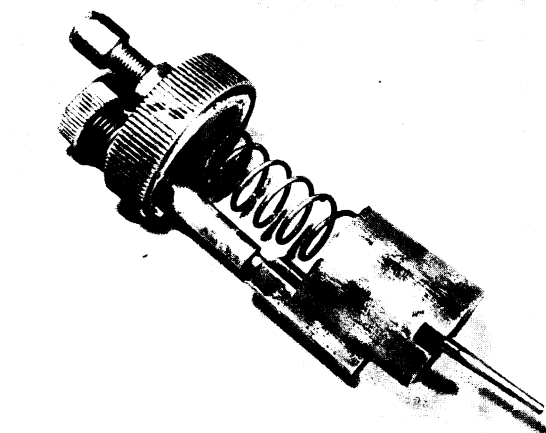
2 As the throttle valve is opened from the idle position, a slight imbalance of the air/fuel ratio occurs. This is inevitable, but is not normally a problem. Some manufacturers, Dellorto for example, have overcome this tendency by incorporating an accelerator pump, whilst the majority have chosen to minimise its effects by careful design and adjustment. With most designs, some compensation is provided by the small well of neat fuel which accumulates around the base of the needle jet. As the throttle is opened, the sudden increase in depression draws this into the engine, thus compensating for the momentarily weak mixture. If, however, the throttle valve cut-away is too large, this will not be enough, and the weakness will cause the engine to spit back through the carburettor, or misfire.

3 If this symptom is experienced, try richening the pilot mixture very slightly. This will usually correct the fault. It is possible that the condition may be caused by the jet needle being set too low, but in practice this is unlikely. Again, it must be stressed that wear in the carburettor will aggravate the

problem. Should the above methods fail to resolve the problem, try fitting a throttle valve with a slightly smaller cut-away. Bear in mind that the throttle valve is usually quite expensive, so try adjustment before resorting to buying new parts. A throttle valve with too small a cut-away will give rise to excessive richness in use; this will be apparent by the engine's tendency to snatch under load at  $\frac{1}{8}$  -  $\frac{1}{4}$  throttle settings. Before a new valve is fitted, try lowering the jet needle by one notch and note whether this has effected any change. If not, a valve with a slightly larger cut-away will be required.



4.9 This Dellorto instrument, fitted to some Moto Guzzi models and many Ducati singles, has a square-section throttle valve



4.10 Amal throttle valve and choke valve assembly (Triumph Tiger Cub)

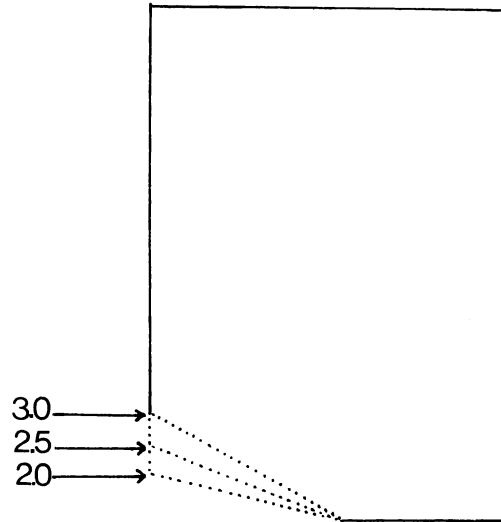


Fig. 4.13 Typical throttle valve cut-away profiles

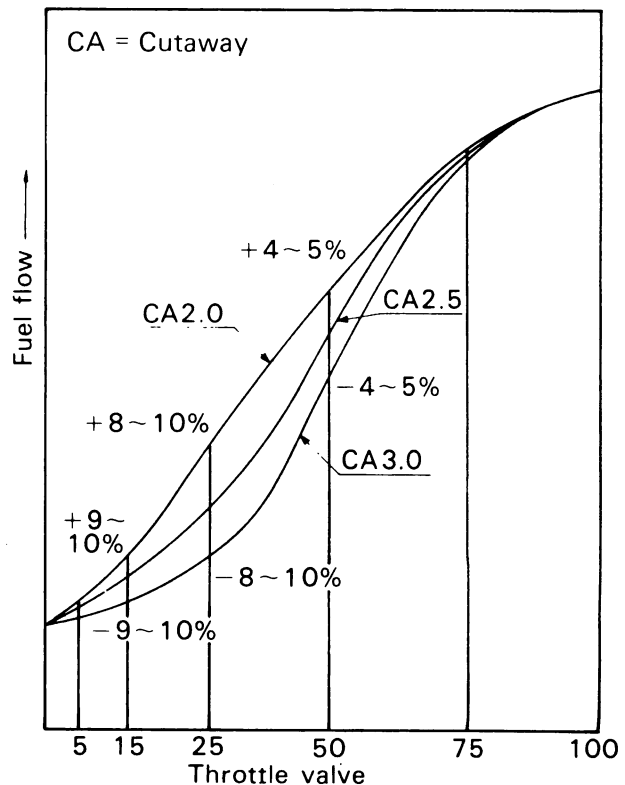


Fig. 4.14 Effect of cut-away types on mixture

**Stage 4: needle and needle jet**

1 The needle and needle jet, in common with the throttle valve, are amongst the very few components which suffer from mechanical wear in normal service. The constant pulsing during induction tends to buffet these three components quite severely, and in time they will wear. In the case of the needle and needle jet, the needle will develop a flat on one face, whilst the needle jet will become oval in section. This will allow a gradually increasing richness to develop leading to excessive fuel consumption, and eventually, to problems in obtaining satisfactory operation. The answer is to renew the needle and the needle jet if any sign of a flat is found on the needle. The cost of replacing these two components is low, and will soon be repaid by improved fuel consumption. It is worth renewing these items as a matter of course, when the carburettor is being overhauled, as the degree of wear is not easily assessed visually or by measurement.

2 To correct maladjustment, or to temporarily compensate for wear, the needle position may be altered. With few exceptions, the jet needle is suspended from the throttle valve and is secured by a small clip which locates in one of a number of grooves. The needle can be lowered to compensate for a fuel-rich mixture by fitting the clip to the next highest groove, or raised to richen the mixture by choosing a lower clip position.

3 Because the needle's position, and the general condition of it and the needle jet, govern the most widely used throttle range, a correct setting is of great importance. Note also that most manufacturers supply a range of needles and needle jets which are designed for numerous applications. If the machine is not new, check that a previous owner has not inadvertently fitted the wrong components. When purchasing these, or any other replacement parts, give the make, year and model of the machine and quote the engine and carburettor type numbers.

**Stage 5: final adjustments**

1 Check that the throttle cable is correctly routed with no acute bends or kinks. Set the throttle cable to give the specified amount of free play. This varies between makes and models, but as a general rule, about  $\frac{1}{8}$  in (3 mm) is usually correct. Check that this adjustment is not taken up by cable movement when the handlebars are turned from lock to lock.

2 Recheck the idle and pilot air screw settings as described in Stage 2. These are always the most difficult to adjust accurately, and it may prove necessary to make minor corrections after the machine has been road tested.

3 Once the carburettor has been set up accurately, make a note of all the settings for future reference. In particular, note the pilot air screw setting in case this adjustment is inadvertently lost, as it will make the subsequent setting-up much simpler. Pilot air screw settings are given as the number of turns out from the fully home position, and generally range from about 1-2 turns.

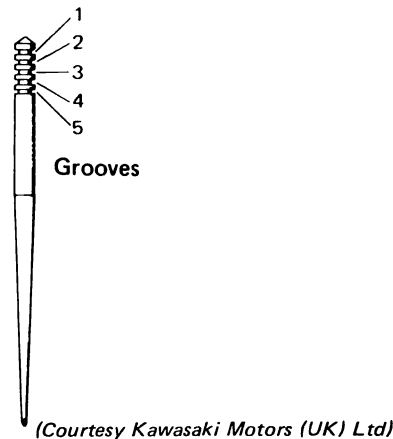


Fig. 4.15 Jet needle clip location grooves

4 Check the carburettor for loose screws or signs of leakage. It is good policy to renew all gaskets and seals when disturbed, although O-rings can normally be re-used many times. Be especially careful to ensure that the carburettor is fitted to the inlet tract securely, as air leaks at this joint will make erratic running inevitable. Where the instrument has a flange fitting, use new gaskets, but take care not to overtighten the retaining nuts, because this will distort the flange and allow air leaks.

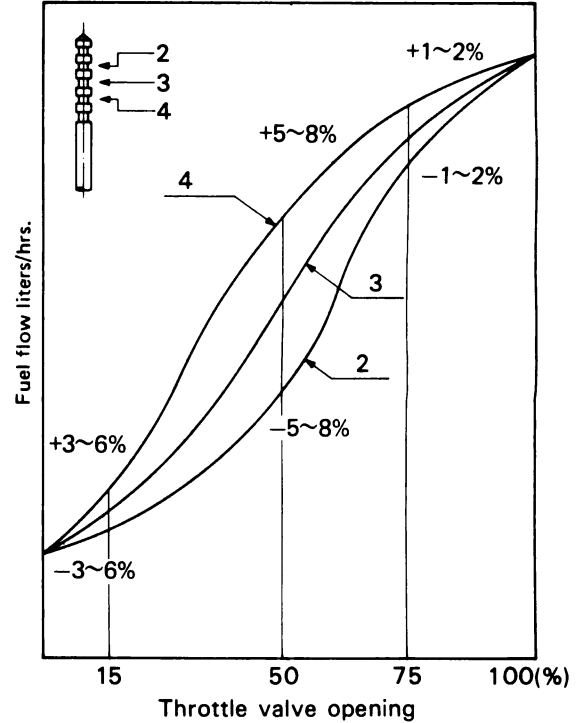


Fig. 4.16 Effects of changing needle position on mixture strength

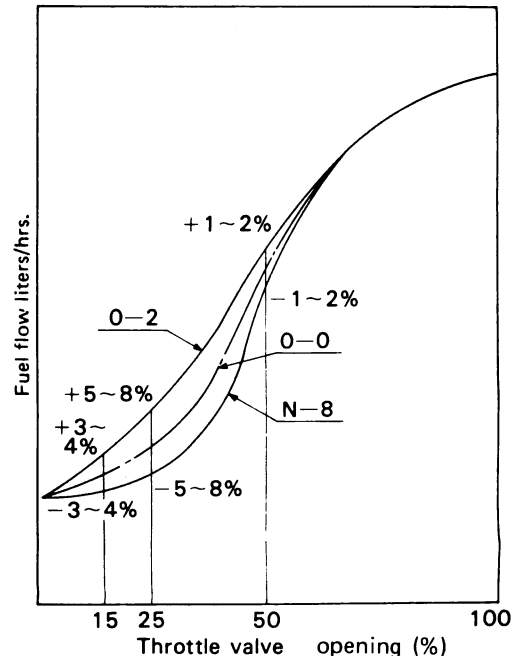
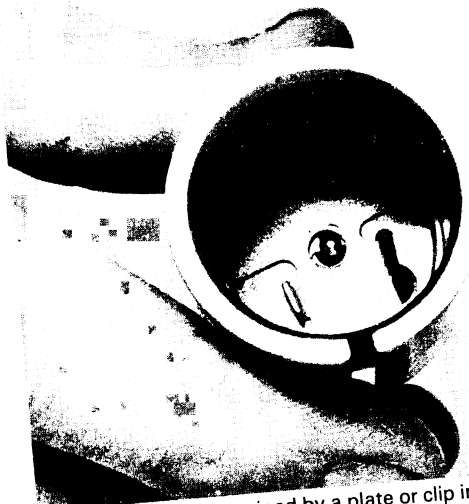


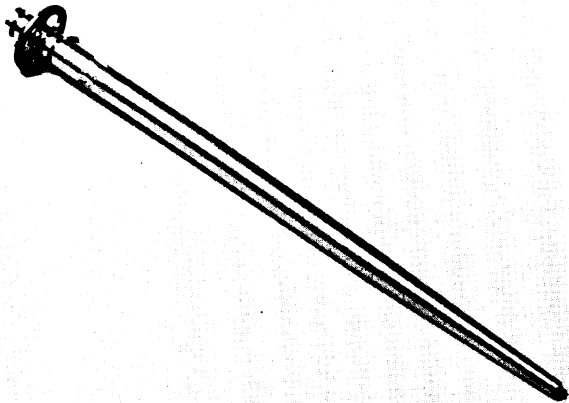
Fig. 4.17 Effects of needle jet changes on mixture strength



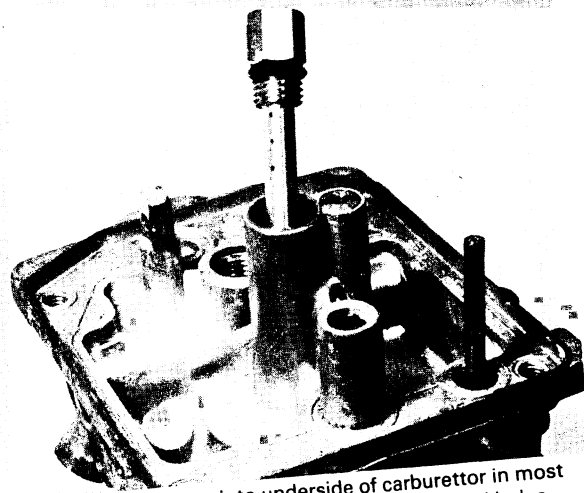
4.11 The jet needle fits through a hole in the centre of the throttle valve



4.12 The needle is retained by a plate or clip in many cases



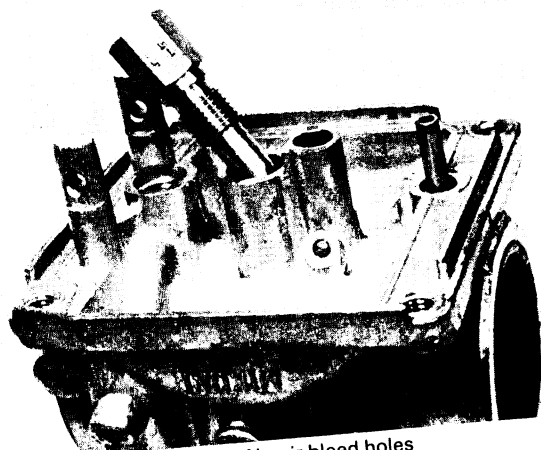
4.13 Needle adjustment is effected by moving locating clip to another groove



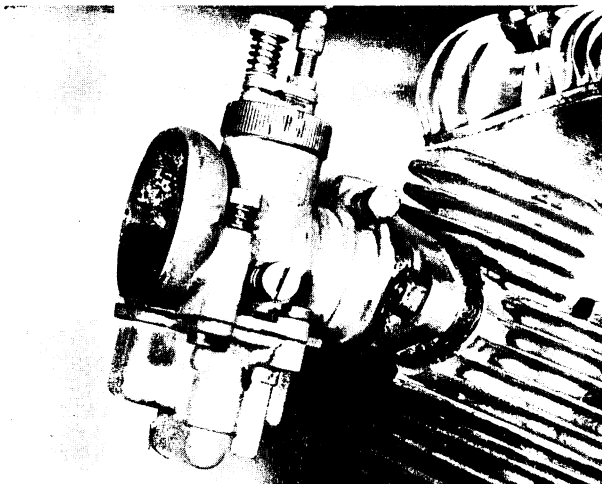
4.14 Needle jet screws into underside of carburettor in most cases. This one is for four-stroke use – note air bleed holes



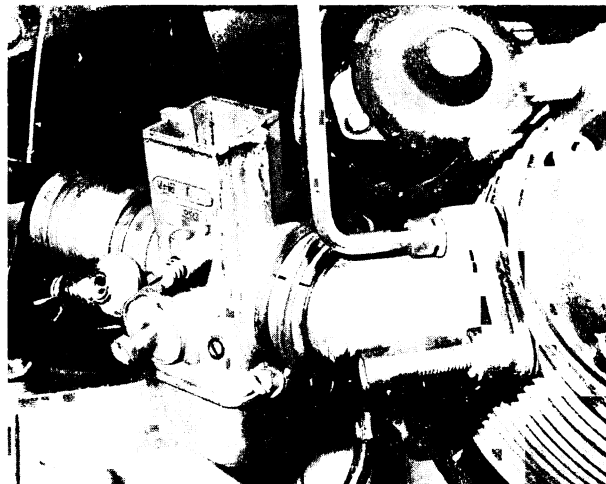
4.15 Another four-stroke type needle jet – Dellorto



4.16 A two-stroke needle jet. No air bleed holes



4.17 Check for air leaks at the inlet tract – especially where there are two joints which might leak, as in the case of this Triumph Tiger Cub.



4.18 Take care not to over-tighten flange fittings – they will distort and leak

#### 4 Tuning single carburettors – two-stroke engines

When dealing with two-stroke engines, the procedure for tuning differs from that given for four-strokes in a number of respects. Most importantly, the plug colour method of checking for correct combustion is affected by the presence of oil in the combustion chamber. This is most evident where the pre-mix method of lubrication is employed, but also applies to pump-lubricated engines to some extent. In consequence, the oil which is burnt during combustion will have some effect on the electrode deposits, and as a rule, two-strokes tend to run 'blackier' than their four-stroke counterparts. This coloration is also dependent on the type of oil used, synthetic oil having different effects than conventional mineral based oils. In view of these problems, the use of plug colour as a guide to mixture strength will be avoided in the tuning procedure.

As with four-stroke engines, the importance of ensuring good general condition and accurate adjustment cannot be stressed too highly. All two-stroke engines are comparatively sensitive to ignition and carburation changes, so check timing and contact breaker gap(s), and fit a new sparking plug before proceeding further. Additionally, remove the cylinder head(s) and decarbonise the engine if this service operation is due, not forgetting to clean the silencer baffles and air cleaner element.

##### Stage 1: main jet

1 Start the engine and allow it to reach normal working temperature. Find a suitably quiet stretch of road where the machine may be ridden in top gear, pulling hard at full throttle. Note that this does not mean that the engine should be 'slogged' in too high a gear, but should be pulling comfortably within its power band.

2 If the main jet is too large, the engine will tend to 'four-stroke', or misfire on alternate strokes. This will result in a noticeable drop in power, and is similar to the effect experienced when the choke, or cold-start device is left on too long. The exhaust will tend to emit a lot of blue smoke, and in extreme cases the plug may foul. To rectify the problem try reducing the main jet by one size and repeating the road test, noting any improvement. Gradually work down in jet size until the four-stroking tendency disappears, at which point the mixture should be almost correct, but perhaps slightly over-rich. It is recommended that a marginally over-rich setting is chosen for safety, because further reductions in size may lead to an over weak mixture, which on a two-stroke engine can wreak havoc with the engine. In normal use, the full main jet capacity is rarely used, so fuel consumption should not suffer noticeably.

3 Too small a main jet is not so easily detected – unless the piston crown becomes holed! The main symptoms to be looked for during the road test are signs of detonation or 'pinking'. What happens is that the engine runs excessively hot due to the weak fuel/air mixture, and eventually the sparking plug or carbon deposits become sufficiently hot to ignite the incoming mixture before ignition takes place. In extreme cases, the effect of this detonation is to hammer and melt its way through the piston crown. This unfortunate result is surprisingly rare where owners have experimented with settings or modified the exhaust or induction systems in a misguided attempt to obtain more power or better fuel economy.

4 Detonation can be heard in the form of a metallic rattle or knocking when the engine is under load, and if noticed during the main jet test, be warned that engine damage **will** occur unless a larger jet is fitted. To play safe, fit a much larger jet, and then work back in size until the resultant 'four-stroking' disappears. Before leaving the rather expensive subject of detonation, it is worthwhile noting that the use of too low a grade of fuel can be another cause of this problem, so can incorrect ignition timing or a badly carbonised engine. So be warned; if detonation is noticed at any time, find out why and resolve the problem before it gets expensive.

##### Stage 2: pilot circuit

1 The main problem of adjusting the pilot mixture and idle speed of any two-stroke engine is that two-strokes do not like idling. Whereas on a four-stroke engine, the incoming mixture is controlled with some precision, this is not the case with the two-stroke, which has a natural tendency to mis-fire at low speeds, and thus idles somewhat haphazardly. Provided that this characteristic is borne in mind, the tuning procedure is much the same as that given for four-strokes.

2 Set the throttle stop screw to give a fast idle speed with the engine at normal running temperature. If starting from scratch, set the pilot mixture screw at its nominal setting, where known, or falling that about  $1\frac{1}{2}$  turns out.

3 Run the engine, and try turning the pilot mixture screw in each direction by about  $\frac{1}{4}$  turn at a time until the fastest and most even idle speed is found. Back off the throttle stop screw to lower the idle speed and repeat the pilot screw adjustment. This process should be repeated until the slowest reliable idle speed is found. Road test the machine, and if a tendency to stall is noticed, increase the idle speed slightly until it is eliminated. As with four-stroke engines, a hopelessly erratic idle speed often indicates carburettor wear or imprecise ignition operation.

**Stage 3: throttle valve cut-away**

1 The procedure for selecting an appropriate throttle valve cut-away on a two-stroke engine is identical to that described for four-stroke engines in the preceding Section, and reference should be made to it for tuning purposes. Take note of the remarks made concerning the need for changing throttle valves, as this applies equally to two-stroke machines.

**Stage 4: needle and needle jet**

1 These components often differ in design to those used on four-stroke applications using essentially the same instrument. This is to suit the specific requirements of the different types of engine, and care must be taken to obtain the correct replacement parts when these are required. When checking or adjusting the needle position and the condition of needle and jet, refer to Stage 4 of the preceding section for details. The tuning procedure is the same regardless of engine type.

**Stage 5: final adjustments**

1 As with the last two stages, the details given in Stage 5 for four-stroke tuning can be applied with equal relevance to two-strokes. The following additional points should be noted. On pump-lubricated machines always ensure that the pump is working effectively and that it is correctly synchronised with the carburettor. On pre-mix, or petroil, systems ensure that oil is mixed at the prescribed ratio. In each case, an excess of oil will **not** benefit the engine, and at worst could lead to engine seizure. This is because the additional oil displaces a corresponding amount of petrol during combustion, and in effect produces a weak mixture. The effects of this have already been discussed.

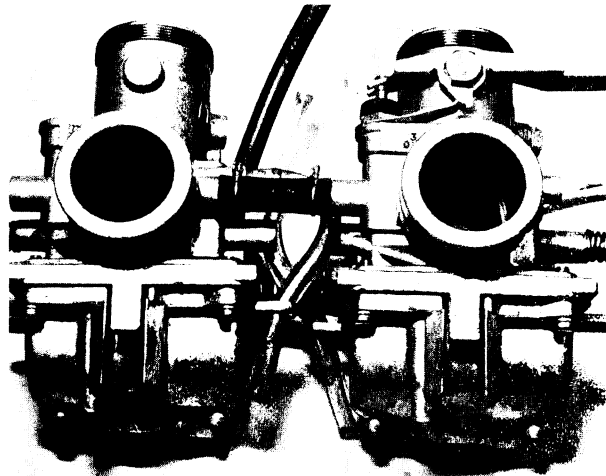
2 On two-strokes and four-strokes, a dirty air cleaner will cause a rich mixture, and so the element should be cleaned or renewed prior to tuning. Likewise, the silencer baffles must be kept clean, as a build-up of oily carbon will create an excessive amount of back pressure, and this too will upset carburation. On no account should the silencer baffles be removed completely in the hope that the extra noise produced is indicative of extra power. This is usually not the case, because the silencer will have been designed to complement the engine, and not to strangle its performance.

**5 Tuning twin carburettors**

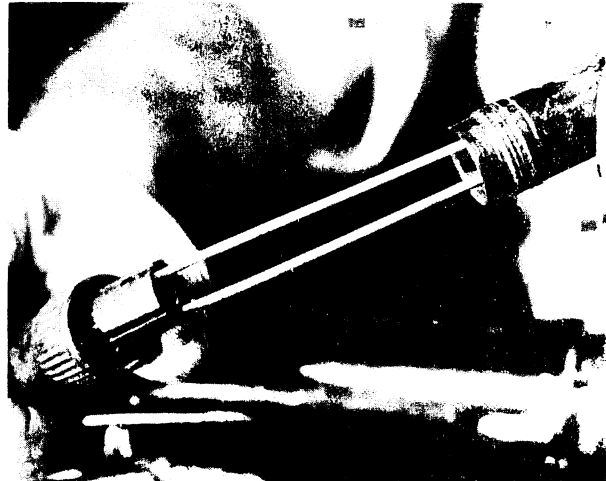
When dealing with machines fitted with twin carburettors, additional accuracy is required because the engine will be sensitive to any slight maladjustment in either instrument. The various tuning stages remain the same as described in the sections on tuning single carburettors, but additional care must be taken to ensure balance between the two instruments. Needless to say, the remarks made earlier in this chapter concerning the general mechanical condition of the machine apply equally to twin carburettor arrangements.

Commence by checking and adjusting the operating cable or cables. A number of arrangements may be found here, ranging from a twin-pull twistgrip with a separate cable running to each instrument, to a single cable operating a connecting linkage between the two carburettors. A third arrangement utilises a single cable from the twistgrip which enters a junction block or cable splitter beneath the petrol tank. From this, two separate cables emerge and run to the carburettors.

Check that the cable or cables are in sound condition and well lubricated. The routing of the cables is of great importance especially where two separate cables are used. It is necessary to route the cables so that a minimal amount of relative movement occurs between them when the handlebar is turned. If this is not done, synchronisation will be impossible. Slacken off both throttle stop screws so that the throttle valves close completely, then set the throttle cable adjusters to obtain the required amount of free play, ensuring that the throttle valves are kept synchronised as described below.



4.19 Twin Mikuni carburetors. Note that the instruments are 'handed', and that only one is equipped with a cold-start mechanism



4.20 Single cable from twistgrip enters this splitter box to control twin carburetors

**Stage 1: synchronising the throttle valves**

1 It is imperative that the two throttle valves commence opening at **precisely** the same time, and remain in absolute synchronisation at all throttle settings. If even slightly out of step, one cylinder will be trying to run at a different speed to the other, and, as this is impossible, the engine will run very lumpily. Where access permits, this synchronisation may be checked visually, although this method demands a certain amount of experience if accuracy is to be assured.

2 A simpler and undeniably more accurate method requires two steel bearing balls of the same size, a small magnet and two pieces of clean, lint-free rag. Open the throttles fully so that the valves are lifted clear of the main bore. Carefully stuff the rag into each carburettor taking care not to damage or disturb the throttle needle. The rag should be positioned just to the engine side of the throttle valve, so that the latter can close without hindrance but so that the rags block the inlet tract.

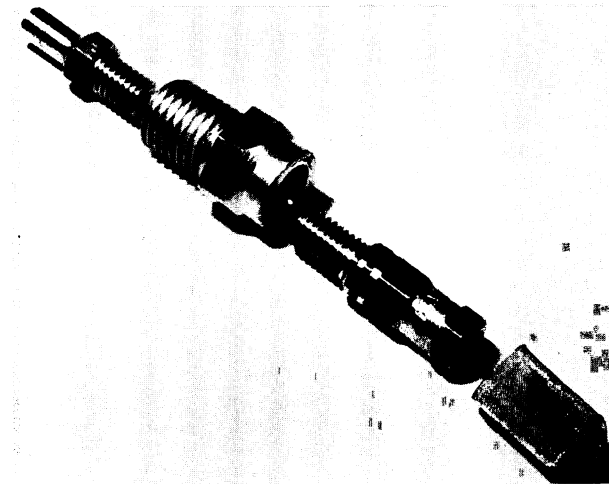
3 Close the throttles and back off both throttle stop screws until they no longer control the valve positions. Place one steel ball in the mouth of each instrument so that it rests against the throttle valve. Open the throttle twistgrip slowly, and note which of the steel balls drops past the throttle valve first. Retrieve the balls using the magnet, and repeat the test having first adjusted the throttle cable of the lagging carburettor by a

small amount. The procedure should be repeated until both balls are released at the same moment, indicating that the two throttle valves are accurately synchronised. Do not forget to remove the pieces of rag from the inlet tract.

4 Next, open the throttle whilst observing one of the throttle valves, using an inspection mirror where necessary. Position the valve so that the edge of the cut-away is just flush with the top of the carburettor bore, and hold this position. If all is well, the remaining valve will be in the same position, indicating that the carburettors are accurately synchronised. If this is not the case, then some discrepancy in the cable routing must be affecting the operation of the throttles. Try rerouting the cables, then repeat the whole synchronising sequence until the valves remain in step throughout the throttle range. Once the instruments have been synchronised, carefully tighten all adjuster locknuts to preserve the setting. With twin cable arrangements, note that any subsequent adjustments for throttle cable free play must be made by moving both adjusters by exactly the same amount, otherwise the synchronisation will be lost. On machines where a splitter is used, make throttle cable free play adjustments on the single cable wherever possible.

### Stage 2: main jet

1 The method of checking main jet suitability is similar to that described for single carburettor engines, earlier in this Chapter. Make a test run at full throttle, stopping the engine quickly, and removing the sparking plugs for examination. On two-stroke machines, the 'four-stroking' method should be used in preference to checking sparking plug colour. In rare cases, or for particularly precise tuning for competition work, it may be found that main jets of slightly different sizes may be required for each carburettor. This, however, is rarely necessary for normal road work, and it is usual to fit main jets as pairs.



4.21 Needle jet, jet holder, main jet and filter gauze – Amal Concentric Mk II

### Stage 3: pilot circuit

1 Having completed the first two stages of the tuning sequence, start the engine and allow it to achieve normal working temperature. Holding the twistgrip open at a fast idle, adjust each throttle stop screw by an equal amount to maintain the setting. Stop the engine and remove one sparking plug, and earth the high tension lead of that cylinder. This latter point is particularly important where electronic ignition is fitted, as the system may be damaged if it is not earthed.

2 Start the engine, which will now turn on the remaining cylinder only. Adjust the pilot air screw and throttle stop screw to give the slowest reliable idle speed, as described in Stage 2 of sections 1 or 2, as appropriate. Where a tachometer is fitted, make a note of the engine speed at this setting, then refit the sparking plug and lead, and repeat the procedure for the remaining cylinder. It is desirable to match the idle speed for

each cylinder, but on machines not equipped with a tachometer, this will not be practicable. In these instances, try to match the two speeds by ear, as far as possible. The idle speed of each cylinder must be approximately the same, or some lumpiness will be experienced as the twistgrip is first opened.

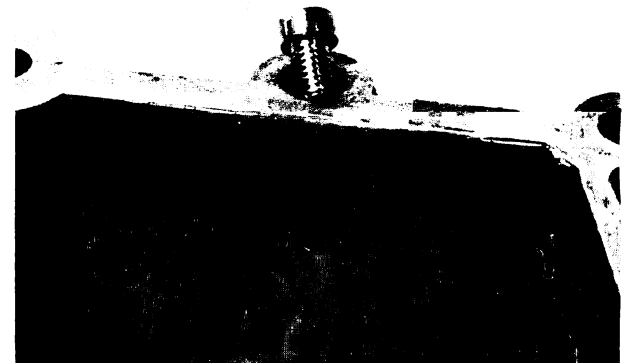
3 Reconnect the remaining sparking plug and lead and start the engine. The idle speed will probably be too high, so reduce this by unscrewing the throttle stop screw by an equal amount on each instrument. Allow the engine to run, and place a hand over the end of each silencer. The pressure from each exhaust system should be similar on a correctly tuned engine. A weak exhaust flow, and/or intermittent misfiring on one cylinder is indicative of imbalance in the pilot system, and the sequence should be repeated to compensate for this.

4 An alternative, and more precise, method of setting the pilot circuit is to use one of the carburettor balancing devices on the market. Not all of these are suitable for use on motorcycles, and of the types available, either a well damped gauge type or a vacuum mercury column manometer is the best choice. These devices allow both instruments to be set up simultaneously and with greater accuracy than by the above method. Whilst the use of this sort of equipment can be considered non-essential but extremely useful when dealing with twin cylinder, twin-carburettor machines, when three or more carburettors are fitted, some form of balancing equipment is indispensable. In consequence, the use of these devices is discussed in detail later in this chapter, and may be applied to twin carburettor arrangements if desired.

5 There is a third possibility for carburettor balancing which is to employ a length of plastic or rubber tubing with which the intake hiss produced by each instrument can be compared by holding the remaining end to the ear. The object here is to adjust the carburettors until the same noise is produced by each. This method can work very well, but demands an experienced ear if it is to be successful. Its use is rapidly declining, and will no doubt join the ancient and forgotten art of bearing scraping in due course. Having said that, any owner interested and patient enough to attempt this method is encouraged to give it a try. Once mastered, it can be just as accurate as any gauge, but in the meantime a degree of persistence will be required.

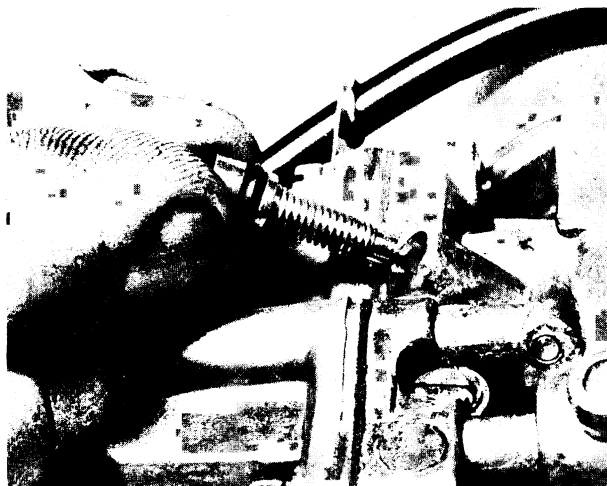
### Stage 4: throttle cut-away

1 The remarks made in Stage 3 of the procedure for tuning single carburettors can be applied here with equal validity. It should be stressed that the condition of the valves is of even greater importance on twin or multi-carburettor systems, because any air leaks will make accurate tuning all but impossible. If it becomes necessary to renew a valve, the remaining component should also be renewed so that the two remain equally matched.

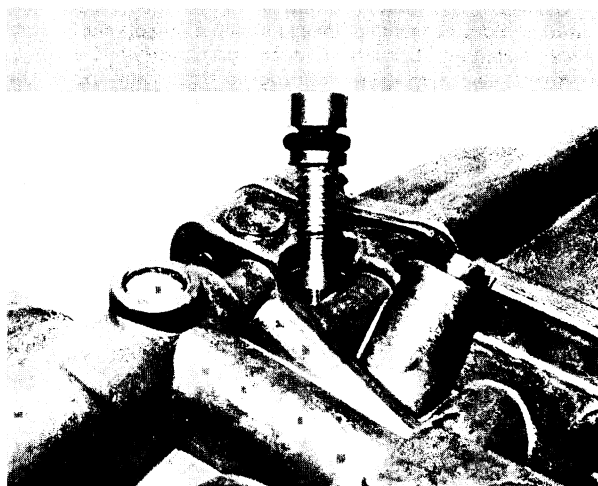


4.22 This Amal Mk II pilot jet is fitted in the float bowl





4.23 The throttle stop screw – Amal Concentric Mk II



4.24 The pilot air screw – Amal Concentric Mk II

### Stage 5: needle and needle jet

1 Refer to Stage 4 of the single carburettor tuning Section for details of this procedure. Additional points which should be noted are that the needle and needle jet must be treated as a pair, and any adjustment made to one must be applied to the other.

The same reasoning should be applied when renewing these components. Always fit needles and needle jets to **both** instruments to preclude any imbalance. Once again, wear will make tuning very difficult, or even impossible.

### Stage 6: final adjustments

1 Go over the pilot circuit sequence once more in case subsequent alterations have affected the earlier setting. Of all the tuning stages this, and the initial mechanical synchronisation have a very marked effect on the smooth running of the engine. It will be necessary to be extremely patient with both of these stages if good results are to be expected.

2 When dealing with twin carburettor machines, treat all aspects as pairs to ensure similar performance from each. On machines fitted with separate air cleaners, always clean and renew both at the same intervals to maintain this balance. On vertical twin-cylinder engines, a balance pipe is often fitted to damp out minor variations in depression between the two inlet manifolds. This should be kept in good condition, and renewed if there is any suspicion of air leakage.

## 6 Tuning multiple carburettors

Many large capacity machines now feature three-, four- or six-cylinder engines arranged across the frame, and fed by a suitable array of carburettors. Of the above machines, the most popular configuration is a four cylinder engine employing one carburettor per cylinder. Whilst in theory at least, this is a desirable state of affairs, the glamour begins to pall significantly when the time comes for servicing. The prospect of tuning and balancing a closely-packed bank of four carburettors is, for most owners, sufficiently daunting for them to entrust this work to their local dealer and his diagnostic equipment.

This aversion is not without foundation, because the operation requires great care and patience, not to mention some rather expensive equipment. It is reasonable to state that twin carburettors are as much as the average mechanic can deal with unaided. As the number of instruments rises, the more critical the balance and synchronisation between them becomes. Where vacuum gauges are a useful accessory for

setting up twin carburettors, they become just about essential when dealing with more than this.

As mentioned previously, there are a number of options open to the owner of multi-cylinder machines, of which the easiest is to take the machine to a reliable dealer for carburettor tuning. Given skilled operators and the sophisticated diagnostic equipment available at most large dealers, this may well prove to be the best decision. Most owners of these multi-carburetted machines, having bought this book, will be keen to overcome the problems inherent in tuning their machines, and so we shall dwell no further on avoiding them.

The second easiest solution to the problem, though by far the most costly, is to obtain a set of vacuum gauges. These devices are expensive. They can be bought as manufacturer's service tools, and in this form will be completely suited to the machine in question, requiring no adaptors or modification. Somewhat cheaper than the above are the various after-market vacuum gauge sets, which vary in price and quality. These can be found advertised in the motorcycle press and are available from the larger motorcycle shops specialising in tools and accessories. The decision whether or not to purchase this type of equipment must be left to the individual. On the one hand, it will mean a large outlay on infrequently used and specialised equipment, whilst conversely the money spent will be saved after about ten hours of what would have been professional tuning. As mentioned before, a good way of obtaining this type of equipment is to form a small syndicate of owners of multi-cylindered machines, who can then share ownership at a greatly reduced individual cost. Some motorcycle clubs purchase special tools for the use of the members. As a last resort, a particularly well-disposed and helpful dealer might agree to hire or lend the equipment during a weekend or evening.

Another alternative which will appeal to the more resourceful and cost conscious reader, is to fabricate a vacuum gauge set using the relatively cheap car type gauges available from most motor accessory shops. If the worst comes to the worst, it is even possible to make do with one gauge, checking each cylinder in turn. These last possibilities will be discussed more fully in Chapter 11.

In addition to the aforementioned vacuum gauges, a certain amount of information will be required for the machine in question, and to this end a workshop manual is invaluable. It goes without saying that the machine must be in good mechanical condition, and that all routine service adjustments are attended to **before** carburettor tuning is attempted. Spend a little time finding out which screws control what on the carburettor bank. On most machines, access is made much easier by propping up the rear of the petrol tank so that it does not obstruct the instruments.

Usually, the carburettors are mounted on a bracket and controlled by a connecting linkage which connects the throttle valves together. Lever-type slide carburettors are often employed, each having a small rocker arm in the top of the mixing chamber to translate the turning movement of a connecting shaft into vertical movement of the throttle valves. Some means of adjustment, usually a small screw on each rocker arm, is fitted to provide individual adjustment of each valve in relation to the connecting shaft, thus providing a means for obtaining mechanical synchronisation. Throttle stop adjustment is made to each instrument simultaneously by way of a single screw or knurled knob.

As with single and twin carburettor installations, the instruments must be in good condition before any tuning attempt is

made. It will be obvious that any overhaul work must be carried out as a precursor to tuning, and this should apply even if the instruments have been functioning acceptably for a long period beforehand. If it proves necessary to fit any replacement parts, this should be applied to all of the carburettors to ensure uniform operation. The float height of each instrument should be checked, with the carburettor bank in position on the engine where the level tube method is employed. In this instance, the level tubes can all be held against one of the outer instruments for convenience. Ensure that the machine is standing on an even, level surface before measuring the fuel levels. Where the method of measurement requires the float to gasket face distance to be checked, this will entail the removal of the instruments as an assembly in most cases.

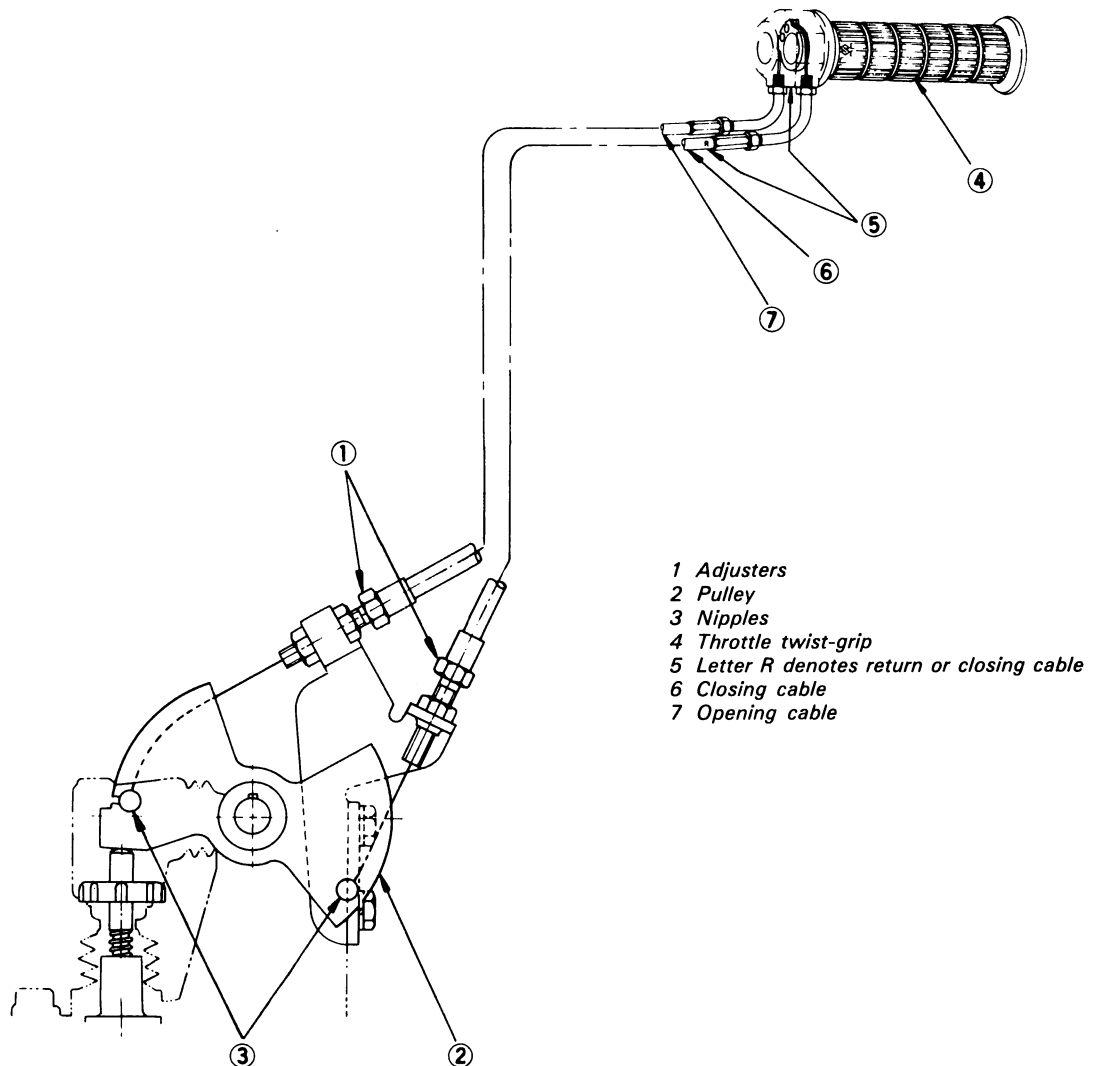
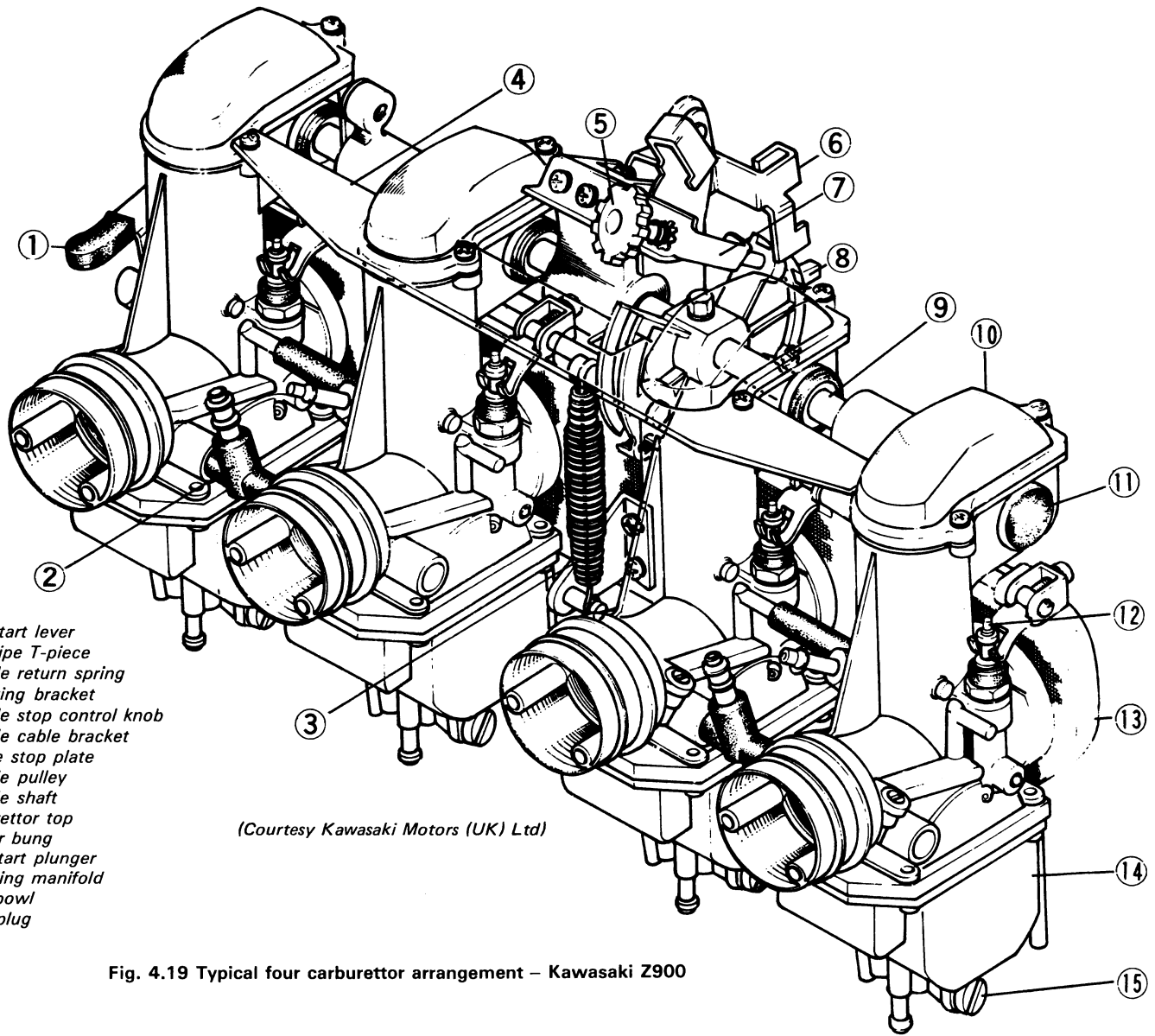


Fig. 4.18 Typical throttle cable arrangement on multi-cylinder machine



- 1 Cold-start lever
- 2 Fuel pipe T-piece
- 3 Throttle return spring
- 4 Mounting bracket
- 5 Throttle stop control knob
- 6 Throttle cable bracket
- 7 Throttle stop plate
- 8 Throttle pulley
- 9 Throttle shaft
- 10 Carburettor top
- 11 Rubber bung
- 12 Cold-start plunger
- 13 Mounting manifold
- 14 Float bowl
- 15 Drain plug

(Courtesy Kawasaki Motors (UK) Ltd)

Fig. 4.19 Typical four carburettor arrangement – Kawasaki Z900

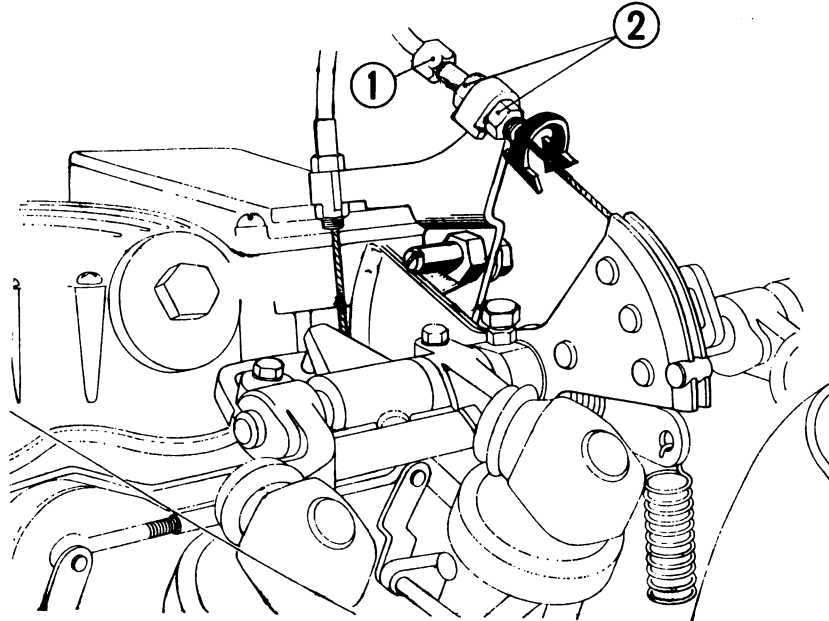


Fig. 4.20 Typical cable adjuster arrangement – Honda CB750 K4

1 Adjuster

2 Locknuts

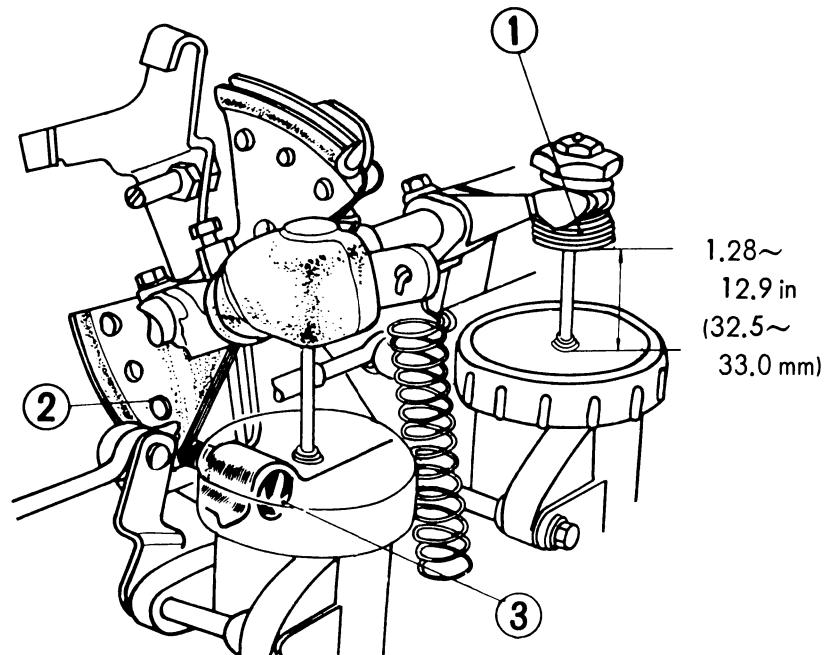
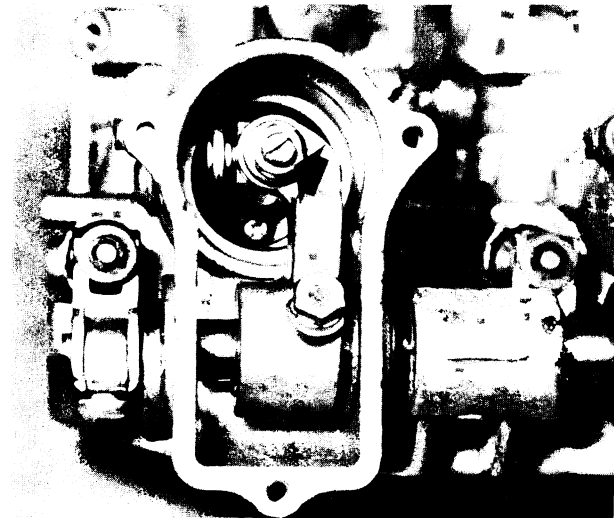


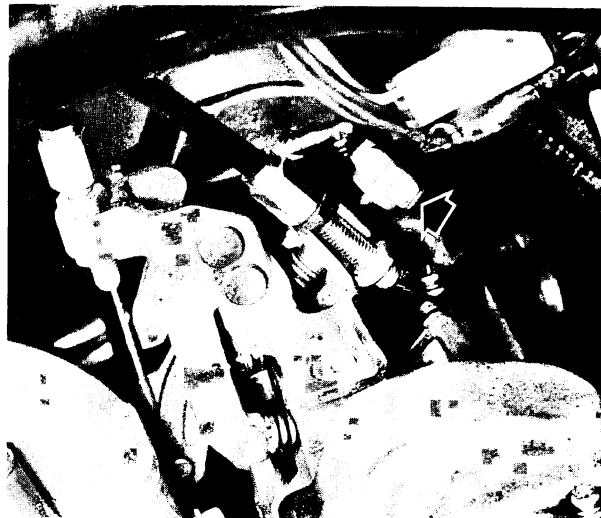
Fig. 4.21 Individual throttle stop adjustment – Honda CB750 K4

1 Individual adjuster arrangement  
2 Pulley

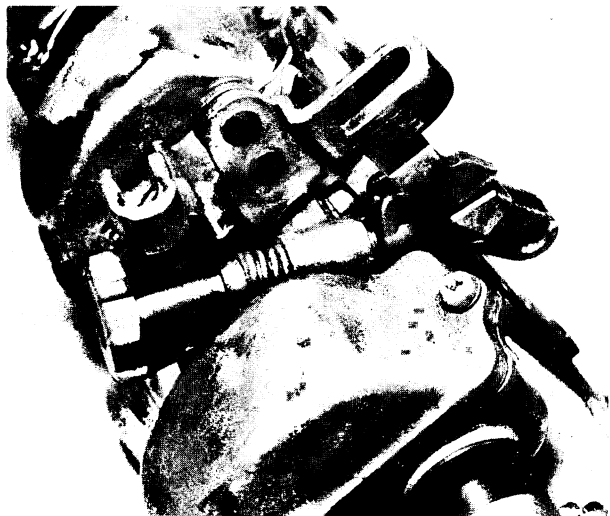
3 Common throttle stop screw



4.25 Where lever, or rocker arm, carburetors are fitted, a screw and locknut provide adjustment to individual throttle valves



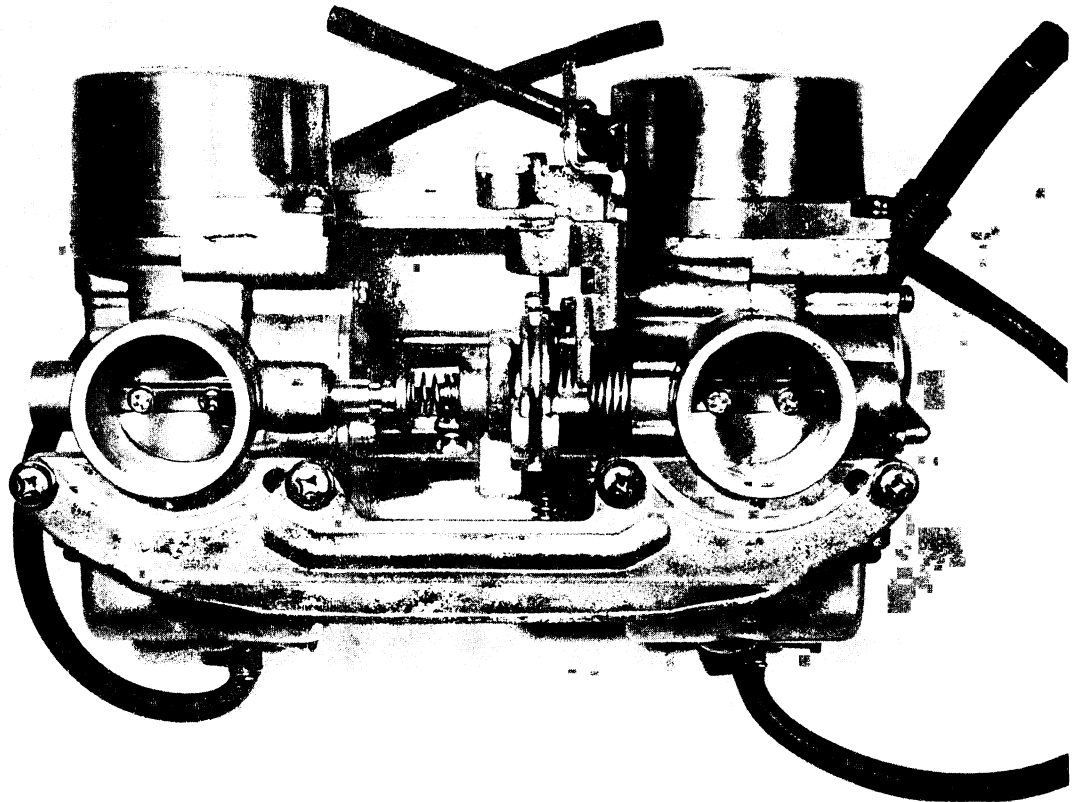
4.26 A typical four carburettor arrangement (Suzuki GS750) showing throttle cables and pulley, and the master throttle stop control knob (arrowed)



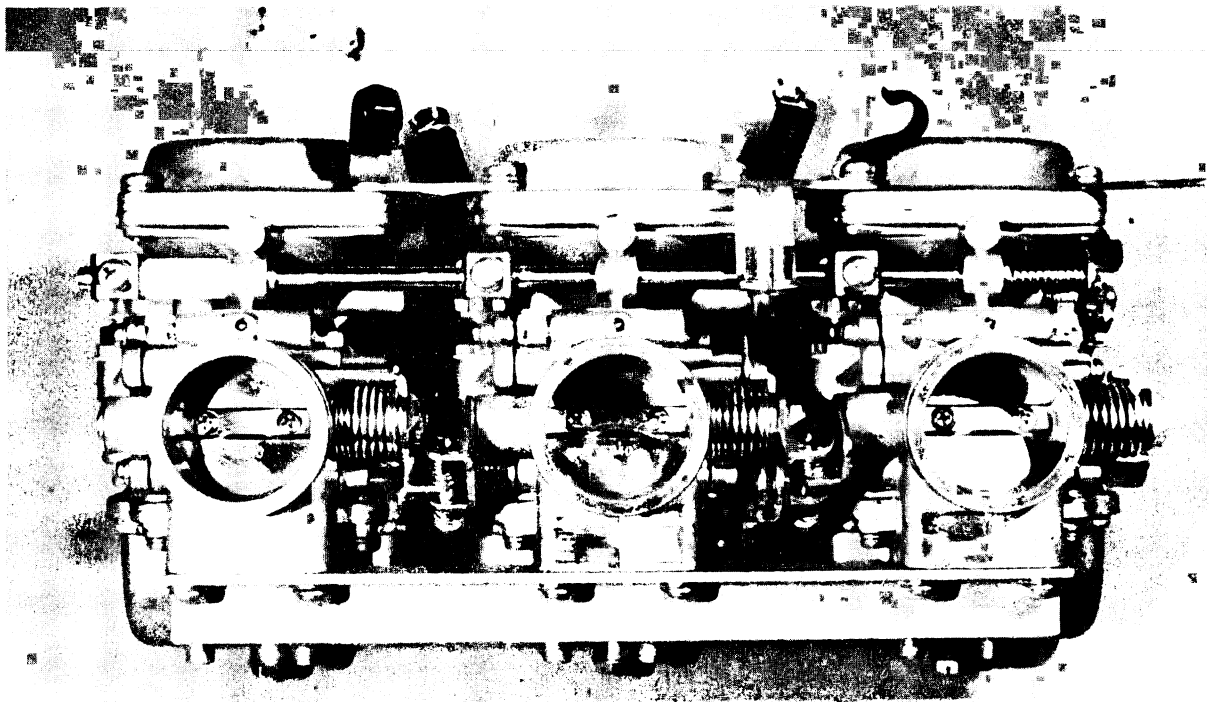
4.27 Master throttle stop control (Kawasaki Z650)



4.28 Pilot mixture screws are often located on underside of float bowl, as on this Kawasaki Z650



Twin CD carburettor installation – S.U. type



Triple CD carburettor installation – Stromberg type

# Chapter 5

## The Constant Depression Carburettor

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As with most aspects of carburation, the **Constant Depression** (CD) carburettor is fraught with ambiguities. In this case, the term chosen to describe its operational principle is open to discussion, and in consequence it has acquired a number of names, most of which are equally appropriate and correct. This particular type of instrument is known variously as constant velocity (CV), constant vacuum (also CV), variable venturi (which does not describe it adequately) and the aforementioned constant depression (CD).

The most popular of these has been chosen, and will be used henceforth. It also has the added advantage of describing very nicely the likely result of the reader trying to fathom why an unsuspecting carburettor should be the subject of such diverse nomenclature. To avoid any further depression, let us begin by establishing in what respects the CD instruments differ from the simple slide instruments.

We have seen how the simple slide carburettor developed over the years, and how various innovations and improvements led to an instrument that is reasonably accurate over a wide range of throttle openings and engine loads. This type of carburettor works quite satisfactorily for most of the time, has the great virtue of simplicity, and will no doubt be with us for many years to come. It does, however, have failings.

If the engine is running fairly slowly in top gear, and the rider wishes to accelerate, he will do one of two things to achieve this. He may simply snap the throttle open, wait while the engine coughs, and then regains control and begins to accelerate. Alternatively, he may select a lower gear, thus raising the engine speed, and accelerate smoothly by opening the throttle progressively. The course of action chosen is dependent solely on the rider's experience and mechanical sympathy. In the latter case, the carburettor coped well enough, progressing smoothly through its operating range as the engine speed and venturi size increased. In the former case it did not, and for the following reasons.

Just before the throttle was opened abruptly, the valve was almost closed and the volume of air passing through the restricted venturi was low, as was the volume of fuel which was being drawn through the pilot circuit. When the throttle valve was snapped open, the effective choke area became very much greater. The volume of air passing through the venturi, being governed by the engine's speed, remained much the same, but as it was now passing through a much larger venturi, its velocity became greatly reduced.

At this stage, the pilot circuit will have ceased to operate, but as the air speed is so low there will be insufficient depression to draw fuel through the main fuel circuit. As a result of this, the mixture will be extremely weak, and combustion will be erratic or non-existent.

Normally, the engine will just splutter for a while and then pick up again, but in extreme cases it will stall completely. Most slide carburettor-equipped machines will exhibit this fault if the throttle is snapped open suddenly when the engine is at tickover.

This problem demonstrates dramatically that slide carburettors depend to some extent on the rider operating the throttle in a manner which is compatible with the engine. Fortunately, few riders choose to go around proving this deficiency in the course of normal riding, and in this respect it is of little significance. The problem exists, however, on a more subtle and more important level, and simply means that for optimum combustion and economy, the throttle opening **must** suit the engine's demands. No rider can claim to be able to achieve this consistently all the time, with the result that there is a certain amount of power loss and wasted petrol during normal riding. This latter point is of increasing significance as

fuel supplies dwindle, prices rise and concern over hydro-carbon emission mounts.

The answer to these problems would be an instrument which was automatically throttled to suit engine demands, but left engine speed control in the hands of the rider. At first sight, this might seem likely to result in a frighteningly complex carburettor, but in fact the CD instrument solves these requirements with elegant simplicity.

Although it seems a relative newcomer to many motorcyclists, the CD carburettor has been widely used on car engines for a great many years. The CD instrument made what was effectively its motorcycle debut, attached to the Triumph Thunderbird. This was in fact an SU instrument, manufactured specially for motorcycle use. This SU instrument was used for a number of years, but was eventually dropped in favour of the traditional slide type. One suspects that this was largely due to the motorcyclists inherent distrust of anything new, although there were many accounts about the new instrument being 'unreliable'. This may have been true. It was, after all, an innovation as far as production machines were concerned, and may not have been fully developed when it was first launched. It would appear that both Triumph and SU were discouraged, as no further SU equipped machines have yet appeared. Some years later, the CD carburettor appeared again, this time on various Japanese machines. This time they worked, and the motor-cycling public accepted them at last.

There are two basic types, which for the sake of convenient terminology we will call the SU and Stromberg types. Both instruments do a similar job in slightly different ways. Although a CD carburettor is by no means the only possible solution to the problems outlined above, it does resolve them quite neatly, as will be seen.

All CD instruments are essentially similar in function to the simple slide carburettor, but have two important differences. The throttle valve is not connected to the twistgrip in any way, and its action is entirely automatic, governed by the amount of manifold depression. The rider controls the air flow, and consequently the engine speed, by means of a simple butterfly valve located on the engine side of the main piston-type valve.

In the SU types, the mixture chamber is enlarged, becoming an air-tight cylinder, or suction chamber, in which a piston is free to move. The piston is finely machined so that it almost touches the piston walls. The underside of the piston terminates in a throttle valve similar to that of conventional slide carburettors. Near the engine side of the piston is a small drilling leading up into the cylinder.

When the engine is running, the depression created on the engine side of the valve is transferred via the drilling to the space above the piston, creating a slight vacuum. Atmospheric pressure on the underside of the piston pushes it upwards until the two pressures balance out, and the piston is maintained at this height. At lower speeds, little piston movement takes place, the flow rate being controlled by the butterfly valve. If the throttle is opened quickly, the piston does not rise immediately, and thus prevents an excessive amount of fuel or air from being admitted. As the piston rises, the air volume and fuel rate are slowly increased until they match the requirements dictated by the engine's speed and the butterfly valve position.

At high engine speeds and full throttle opening, the piston is drawn fully upwards by the resulting vacuum, leaving the carburettor choke virtually unrestricted and the fuel flow metered by the main jet. Closing the throttle reduces the vacuum effect, and the piston and valve will fall until equilibrium is reached or until the valve reaches its idle position.

It will be noted that if the butterfly valve is opened to a position which does not create sufficient vacuum in the suction

chamber to open the piston/valve further, the throttling is automatically controlled by the latter until the engine speed builds sufficiently to create a differential. In this way, the rider controls the engine by governing the amount of mixture admitted to the engine, rather than controlling the air/fuel mixture directly. If the twistgrip is opened too far, the piston/valve assembly will not do so until engine speed and load conditions permit this.

The second type of CD instrument is the Stromberg type, in which a valve similar to those used on slide carburetors is attached to the centre of a rubber diaphragm. It operates in much the same way as the S.U. type, but does not require such precise machining of the suction chamber, the flexible diaphragm forming an effective seal. This second type has the advantage of a more compact suction chamber, and for this reason is the more popular of the two types for motorcycle applications.

The valve or piston/valve combination plays an important part in tuning these instruments. Not only does the valve cut-away have an effect, but the weight of the valve determines its response to vacuum changes. This characteristic is adjusted by artificially adding to the effective weight by fitting a spring above the valve. It should be stressed that this is **not** a return spring, but a means of choosing a valve response suited to a particular engine.

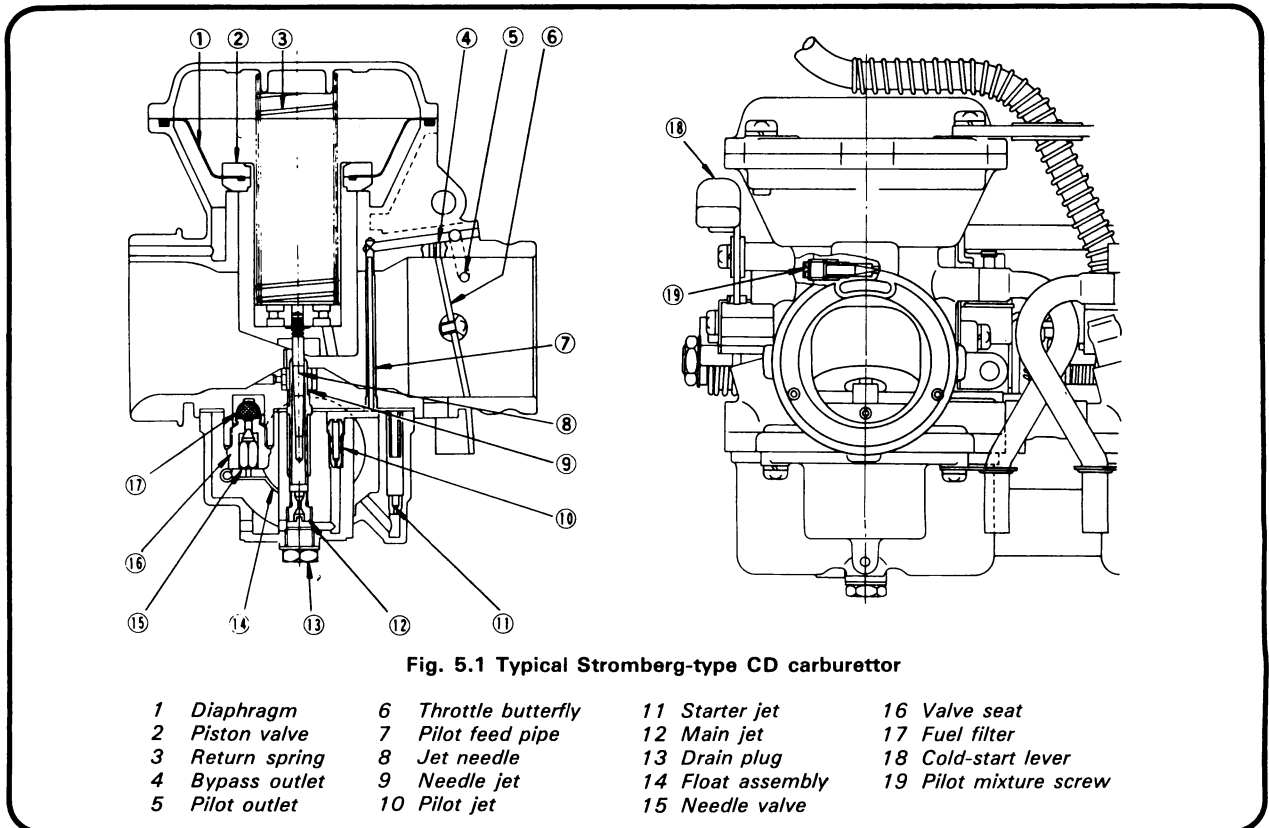
There are a number of hybrid instruments found on motorcycles. One of these is part fixed-jet and part CD in function. At tickover, metering is controlled by a normal pilot circuit, independent of the main carburettor and automatic in operation, as in most instruments. As the butterfly valve is opened, more air is admitted, and fuel is drawn from the primary main jet located on the engine side of the valve. Further opening of the butterfly causes the secondary main jet to be brought into action, this being located centrally in the instrument as in conventional slide or CD types. Up to this point (idle to low speed) the carburettor has functioned as a fixed jet instrument, but from here on, the vacuum induced begins to act on the suction

chamber, and the instrument functions as a CD type. This additional sophistication is designed to give an ever smoother transition between the idle and low speed stages.

Another variation, found on some Honda twins, dispenses with the butterfly valve, the vacuum-controlled valve controlling the engine speed completely. The throttle valve incorporates a small shuttle valve in the air passage which runs up into the suction chamber above the diaphragm. Inside the suction chamber is an arm operated by the throttle cable. When the end of this arm bears upon the top of the shuttle valve, it is held closed, so at tickover the throttle valve is held down by the arm. If the twistgrip is now turned, the valve is allowed to open, and the vacuum will act on the diaphragm, lifting the piston. The carburettor will now function as an ordinary CD instrument until the valve rises sufficiently to close the valve by touching the arm.

It will be seen that the upward travel of the valve is thus controlled by the arm, as is the closing of the throttle. The speed at which the valve opens is, however, dependent on engine load and speed, as with any other CD instrument.

All CD carburetors have a similar jetting arrangement to the slide types. A float chamber is mounted beneath the mixing chamber, concentric to the valve or valve/piston arrangement. A needle is attached to the underside of the valve, operating in conjunction with a needle valve to control the fuel delivery at low speed and intermediate speed settings. Below the needle jet arrangement is the main jet, occasionally supplemented by a primary main jet mounted nearer the engine side of the instrument. The pilot circuit is similar to that used on slide instruments. An air passage, normally controlled by an air jet, passes air into the carburettor via a pilot air screw. Fuel drawn through a pilot jet is mixed with this air stream, and the resulting mixture is admitted via an outlet on the engine side of the throttle and butterfly valves. Cold starting is provided by a richening circuit in the majority of cases, although some form of strangler, similar in construction to the butterfly valve, is occasionally found.





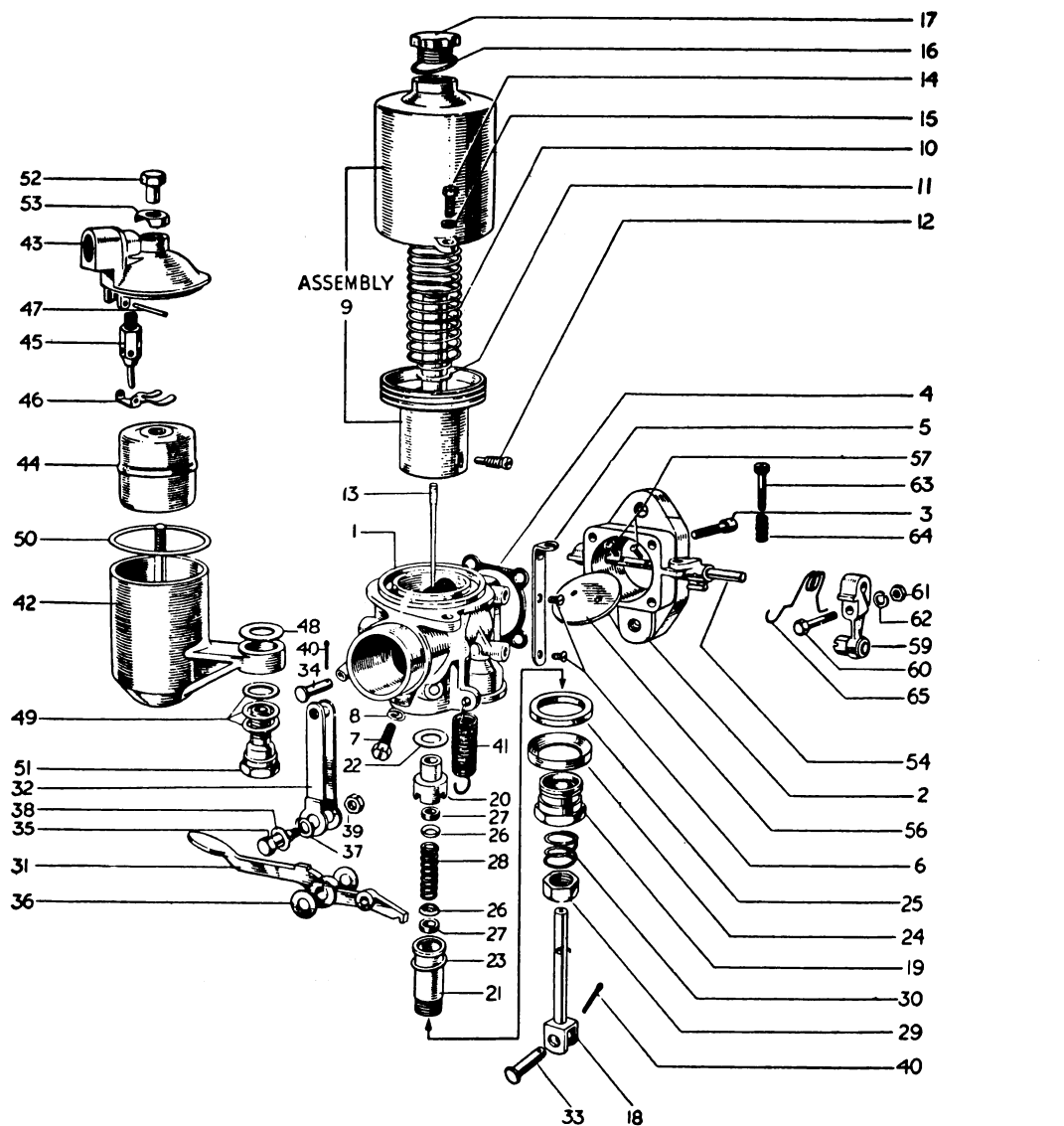


Fig. 5.2 SU MC2

- |                           |                       |                          |                        |
|---------------------------|-----------------------|--------------------------|------------------------|
| 1 Carburettor body        | 18 Jet                | 34 Pivot pin             | 50 Washer              |
| 2 Adaptor flange          | 19 Jet adjuster screw | 35 Bolt                  | 51 Banjo bolt          |
| 3 Screw - 4 off           | 20 Jet bearing top    | 36 Fibre washer          | 52 Nut                 |
| 4 Gasket                  | 21 Jet bearing seat   | 37 Spring washer         | 53 Brass cap           |
| 5 Throttle cable abutment | 22 Copper washer      | 38 Washer                | 54 Throttle spindle    |
| 6 Screw - 2 off           | 23 Copper washer      | 39 Nut                   | 55 —                   |
| 7 Plug                    | 24 Brass sealing ring | 40 Split pin             | 56 Throttle butterfly  |
| 8 Washer                  | 25 Cork sealing ring  | 41 Return spring         | 57 Screw - 2 off       |
| 9 Piston chamber assembly | 26 Brass gland washer | 42 Float chamber         | 58 —                   |
| 10 Piston spring          | 27 Cork gland washer  | 43 Float chamber lid     | 59 Throttle lever      |
| 11 Thrust washer          | 28 Spring             | 44 Float                 | 60 Pinch bolt          |
| 12 Needle locating screw  | 29 Adjusting nut      | 45 Float needle and seat | 61 Nut                 |
| 13 Jet needle             | 30 Spring             | 46 Hinged lever          | 62 Spring washer       |
| 14 Screw - 2 off          | 31 Jet lever          | 47 Pivot pin             | 63 Adjusting screw     |
| 15 Washer - 2 off         | 32 Link               | 48 Fibre washer          | 64 Spring              |
| 16 Sealing washer         | 33 Pivot pin          | 49 Sealing washer set    | 65 Lever return spring |
| 17 Cap                    |                       |                          |                        |

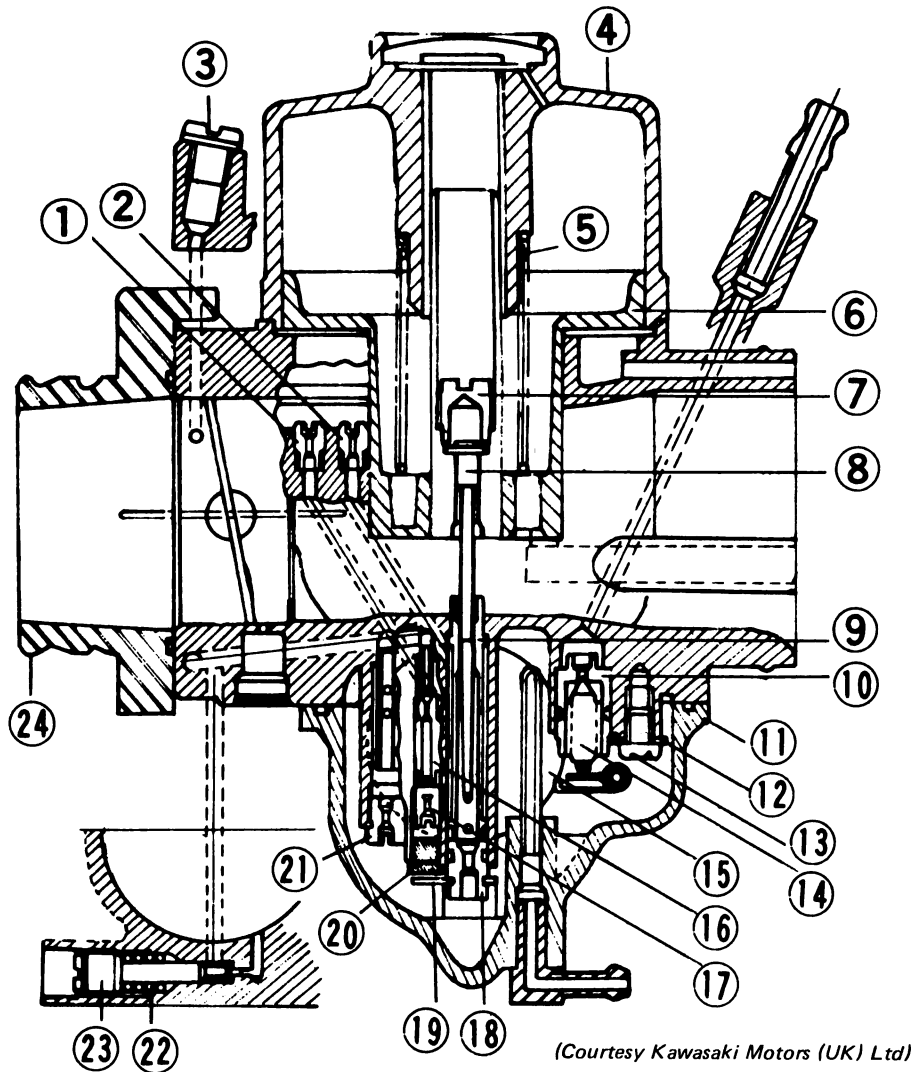
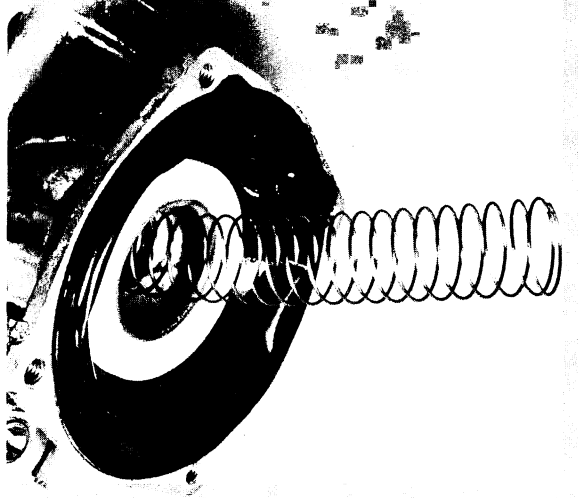


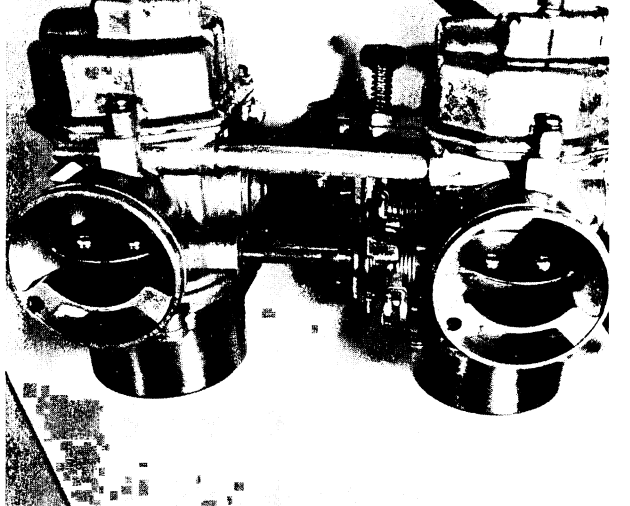
Fig. 5.3 Keihin CVB 36 carburettor – SU type constant depression instrument

- |   |                       |    |                    |    |                |
|---|-----------------------|----|--------------------|----|----------------|
| 1 | Slow air jet          | 9  | Needle jet         | 17 | Pilot jet      |
| 2 | Main air jet          | 10 | Float valve seat   | 18 | Main jet       |
| 3 | Vacuum gauge take-off | 11 | Float bowl         | 19 | Retainer       |
| 4 | Vacuum cylinder       | 12 | Retainer           | 20 | Plug           |
| 5 | Spring                | 13 | Screw              | 21 | Starter jet    |
| 6 | Vacuum piston         | 14 | Float valve needle | 22 | Spring         |
| 7 | Screw                 | 15 | Float              | 23 | Pilot screw    |
| 8 | Jet needle            | 16 | Slow running jet   | 24 | Mounting plate |

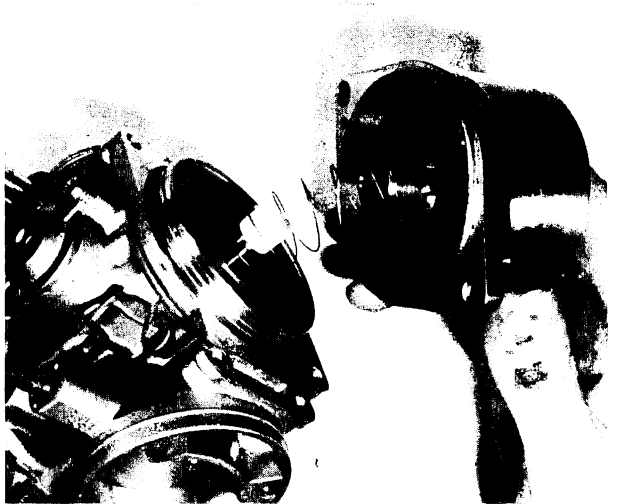
5.5 A flexible diaphragm and spring are housed beneath the top



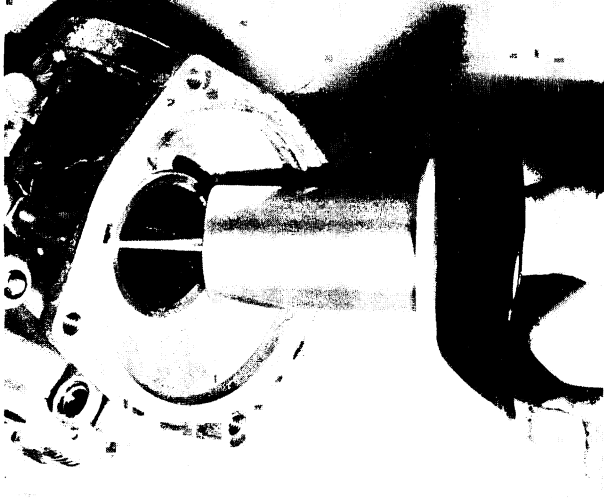
5.3 Engine speed is controlled by means of butterfly throttle valve(s), whilst the piston(s) adjust automatically in response to changes in engine vacuum



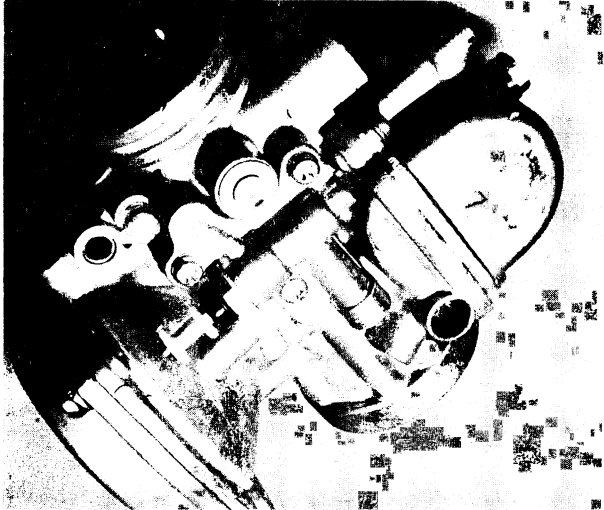
5.1 The SU type carburettor features a vacuum cylinder which takes the place of the mixing chamber top of a slide instrument



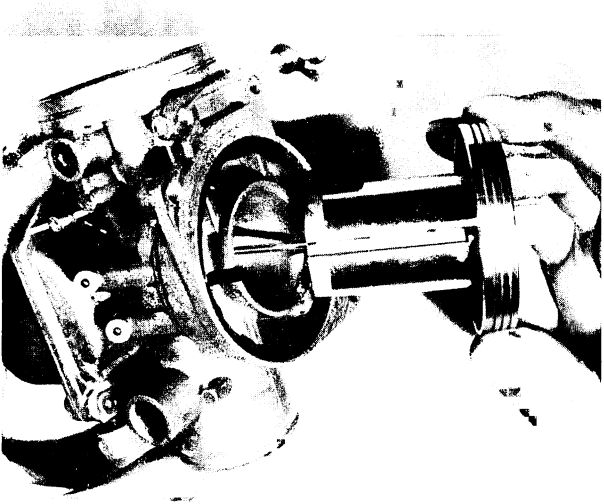
5.6 The throttle valve is very similar to that used in slide instruments

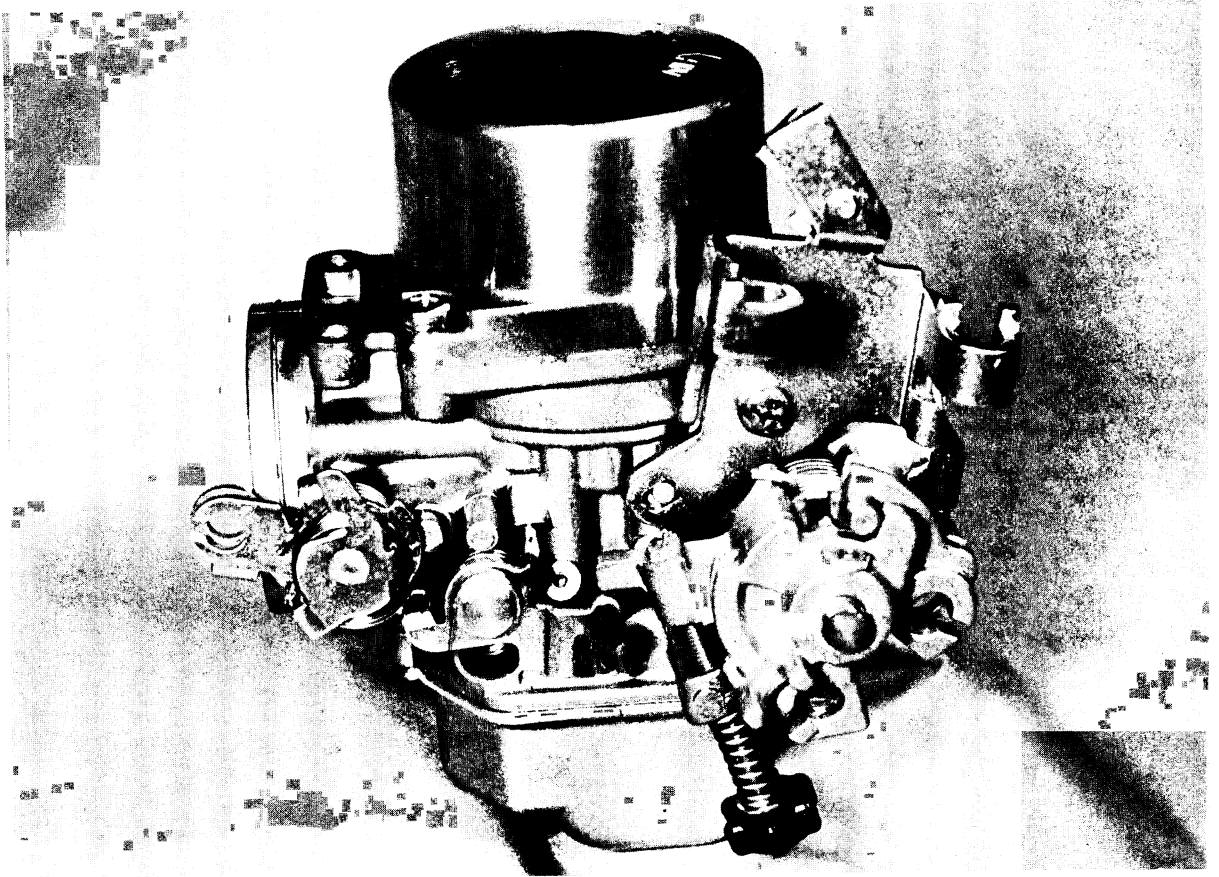


5.4 The Stromberg-type CD instrument is more compact than the SU type, and is favoured for motorcycle applications



5.2 The top of the throttle valve is modified to form a piston which is a precise fit in the vacuum cylinder





The increasingly popular CD carburettor

# Chapter 6 Tuning CD Carburettors

## Contents

Preliminary checks . . . . .	1	Tuning procedure . . . . .	3
Checking the float level . . . . .	2		

### 1 Preliminary checks

As with any other carburettor tuning sequence, attention must first be turned to the general condition of the machine. It must be understood that no amount of tuning can compensate for a worn engine, and such deficiencies must be investigated and rectified first. Equally important is the state of tune of the engine in general. On two-stroke machines, attention must be given to the exhaust baffles and air cleaner, both of which must be cleaned. The engine should be decarbonised if this operation is due, and of course, ignition timing and contact breaker settings should be checked and reset as required. In the case of four-strokes, the silencer baffles do not normally become obstructed, because the exhaust gases are not of an oily nature (if they are, there is something sadly wrong with the engine!). The remaining operations mentioned above should, however, be attended to, and in addition, the valve clearances should be checked.

The condition of the carburettor itself is of great importance, and if the machine has covered a high mileage without attention to the instrument(s), a full overhaul may be desirable. This is of particular significance where the machine runs very badly or consumes an unreasonable amount of fuel. Although an overhaul need not be considered a normal precursor to tuning, it should be borne in mind that much time and effort can be expended during tuning, and this is wasted on a worn or damaged carburettor. If overhaul is considered to be necessary, refer to Chapter 9 for details before proceeding further with the tuning operation.

### 2 Checking the float level

It is important to ensure that the fuel level in the float chamber is maintained at the correct level. If this is not the case, the mixture will be excessively rich or weak throughout its operating range, and thus will affect all subsequent tuning stages.

It is obviously necessary to know the recommended float height setting or fuel level. This information can sometimes be found in the better owners handbooks, but often it will be necessary to obtain a workshop manual or to enlist the help of a friendly dealer to establish the required setting and the method of measurement. Generally speaking, there are two basic adjustment methods, and these are outlined below. It should be noted however, that there are subtle variations of these, so it must be stressed that the **exact** details be checked, along with the setting.

On some instruments, it is the fuel height itself which is measured. This is accomplished by removing a plug near the bottom of the float bowl and attaching a clear plastic sight tube. This can be bought as a manufacturers service tool, but the more resourceful owner can usually improvise with some car windscreen washer tubing and a measure of ingenuity. The tubing is cheap and easily obtained from motor accessory shops. Another source of supply is a home winemaking shop.

With the tube connected up, the reading is taken by holding the tube against the carburettor body and turning on the fuel tap. The level figure is given as a distance below a known datum point, normally the lower face of the carburettor body. Where multiple instruments are fitted, one of the outside carburettors can be used as a common datum for the inaccessible inner instrument(s).

The more common method is to determine the float height, normally measured from the carburettor body gasket face. To carry out this check, it will be necessary to remove the carburettor(s) from the machine, and to release the float bowl. The check is made with the carburettor on its side, so that the valve is **just** closed, or with the instrument fully inverted. The method used depends upon the manufacturer's recommendation.

In either case, the level should be checked with an accurate ruler. The tolerance is normally about  $\pm 1.0$  mm (0.04 in), but it is important where more than one instrument is used, to ensure that the levels are similar on each. If adjustment is required, it is carried out by carefully bending the small metal tang which operates the float valve. It should be noted that the smallest movement here results in a much greater change in float height, so great care must be taken and the new setting checked carefully.

It is important when dealing with carburettors having a double float arrangement that both floats are at an equal height. It is possible for the two to become displaced if the metal support becomes twisted, and care must be taken to avoid this when adjustments are made.

### 3 Tuning procedure

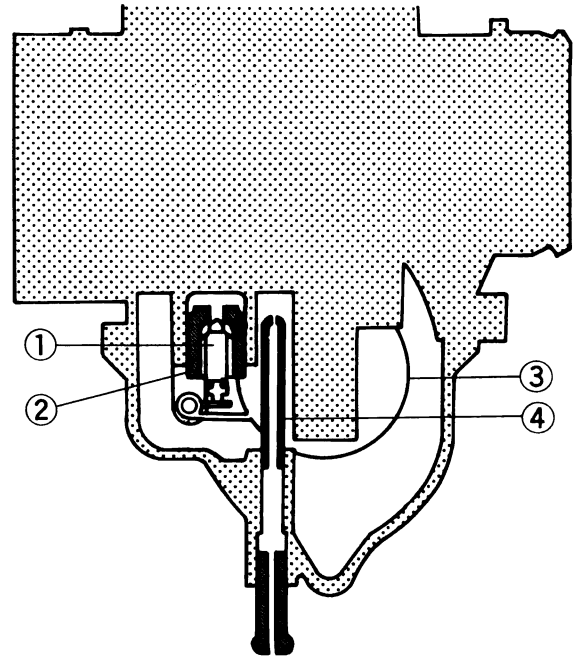
The operational stages, and consequently the tuning stages, are similar for CD and slide-type carburettors, even though throttling is not controlled directly on the constant depression types. It is recommended that the tuning sequences given for slide types are studied before attention is turned to constant depression instruments, as this will help to demonstrate which parts of the carburettor control the mixture ratio at various throttle openings.

The CD carburettor is normally employed on machines having two or more cylinders, and as the tuning procedure is largely similar regardless of the number of carburettors employed, the various permutations will be dealt with together. Let us begin by considering the various operating stages, and the means of adjusting the mixture ratio at each.

At tickover, or idle, the piston/valve is at its lowest point. The butterfly valve is almost closed and is resting against the throttle stop screw which has been set at a suitable engine speed. Air is drawn through the carburettor past the piston/valve assembly, which exerts no effect at this speed. The air is restricted by the butterfly valve, behind which there exists sufficient depression to draw a fuel/air mixture through the pilot system. This ratio is controlled by a pilot mixture screw, and in some cases by a pilot air jet which determines the initial flow rate of air passing through the system. The pilot jet controls the fuel delivery from the float chamber.

As the twistgrip is turned, the butterfly valve begins to open, and a larger volume of air is admitted to the engine. The airflow is now restricted at the piston/valve which will open slightly to compensate for the increased depression behind it. The pilot circuit will cease to operate during this intermediate stage, and fuel will now be drawn through the primary main jet, if fitted, or through the needle jet. At this stage, adjustment is made by altering the needle position (where this is possible), changing the primary jet size (where applicable) or by controlling the effective piston weight by fitting a spring of different tension.

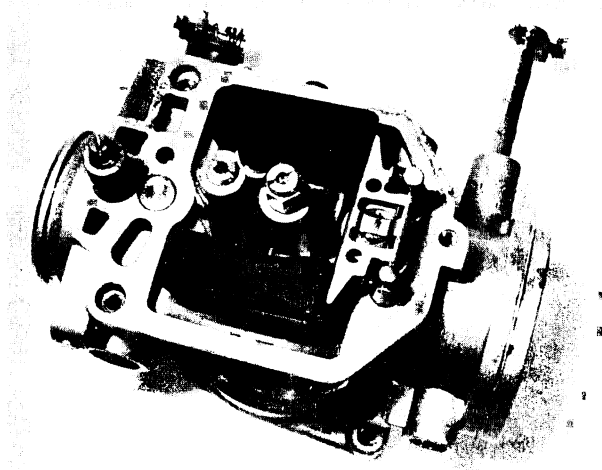
As the butterfly valve opens fully, the piston/valve assembly will rise to a position governed by the engine load and speed. Eventually, the needle jet and needle will cease to affect the fuel flow from the main jet, and this will become the controlling factor. The amount by which the piston/valve opens is still dependent on its effective weight, and it will be seen that this component has a significant effect at all but idle speeds.



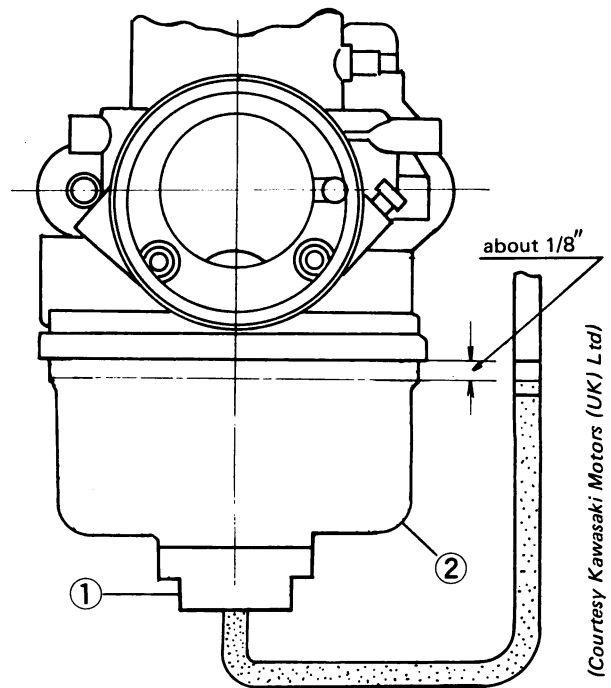
(Courtesy Kawasaki Motors (UK) Ltd)

Fig. 6.1 Float system

- 1 Float valve
- 2 Valve seat
- 3 Float
- 4 Overflow pipe



6.1 Typical float system (Honda twin)



(Courtesy Kawasaki Motors (UK) Ltd)

Fig. 6.2 Fuel level measurement

- 1 Drain plug adaptor and tubing
- 2 Float bowl



6.2 Adjustment is made by bending tang to which float needle is anchored

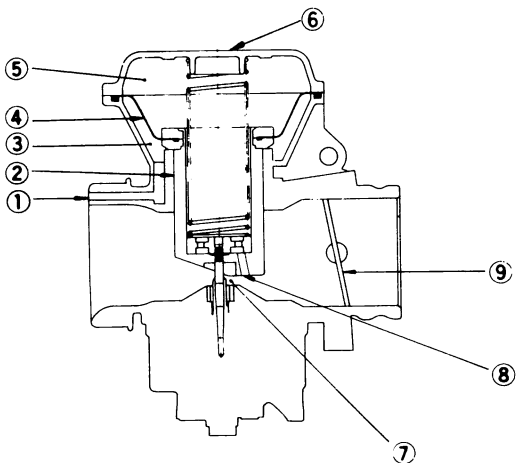


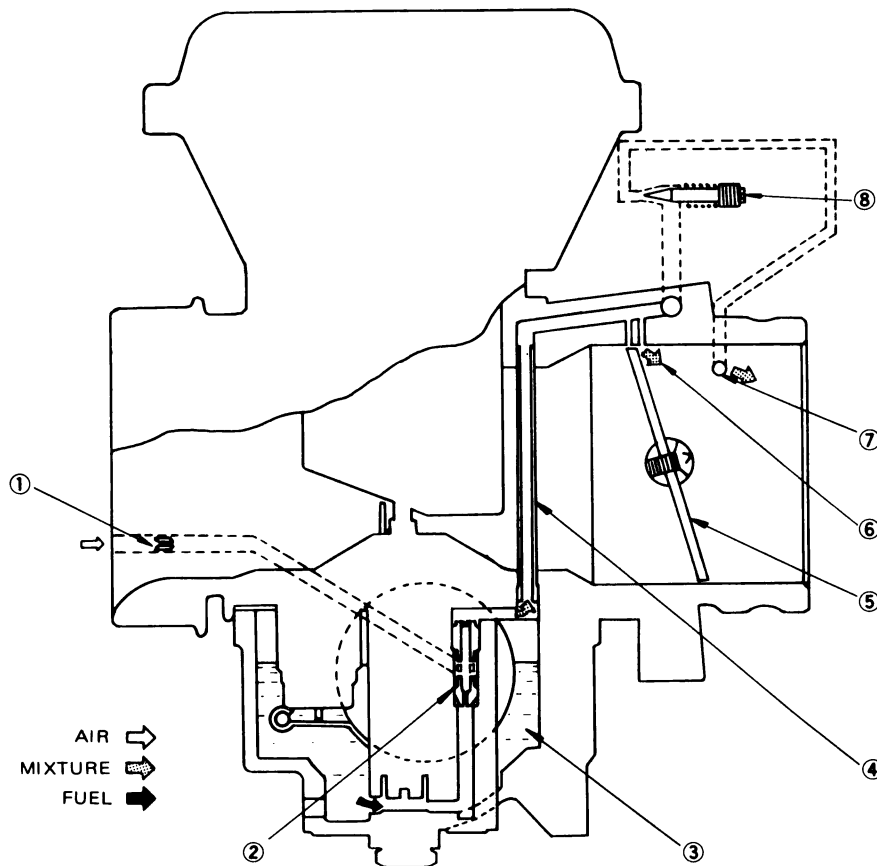
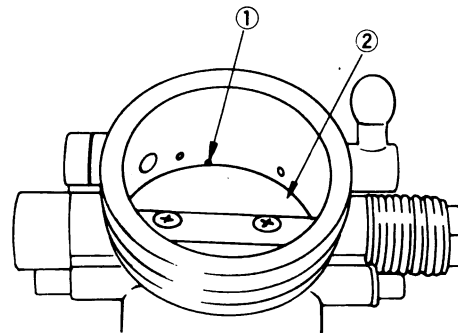
Fig. 6.3 Low speed operation – CD carburettors

At low speeds the throttle butterfly (9) will be almost closed and airflow through the instrument will be low. Vacuum in the carburettor bore, and consequently above the diaphragm (4) will be low, and air entering the passage (1) to the area below the diaphragm (3) will not produce much movement of the piston valve (2). Vacuum effect is highest on the engine side of the piston valve (7), and a vacuum port (8) conveys this to the vacuum chamber (5). A spring between the vacuum chamber cover (6) serves to hold the piston down under low vacuum conditions such as this.

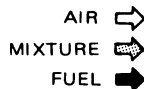
If the butterfly valve is ignored for a moment, it will be noted that the main bore is behaving just like a slide carburettor at low speeds.

Fig. 6.5 Pilot system outlets

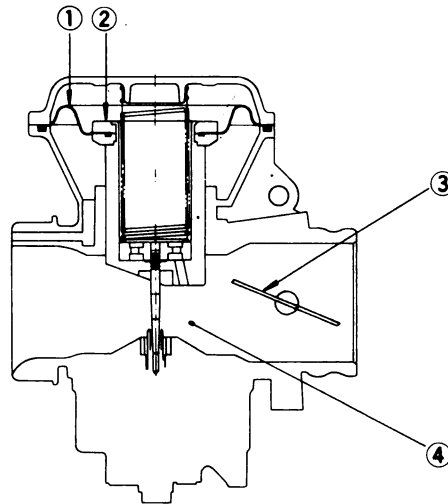
- 1 Bypass outlet
- 2 Throttle butterfly
- 3 Pilot outlet



- 1 Pilot air jet
- 2 Pilot jet
- 2 Float chamber
- 4 Pilot pipe
- 5 Throttle butterfly
- 6 Bypass outlet
- 7 Pilot outlet
- 8 Pilot mixture screw

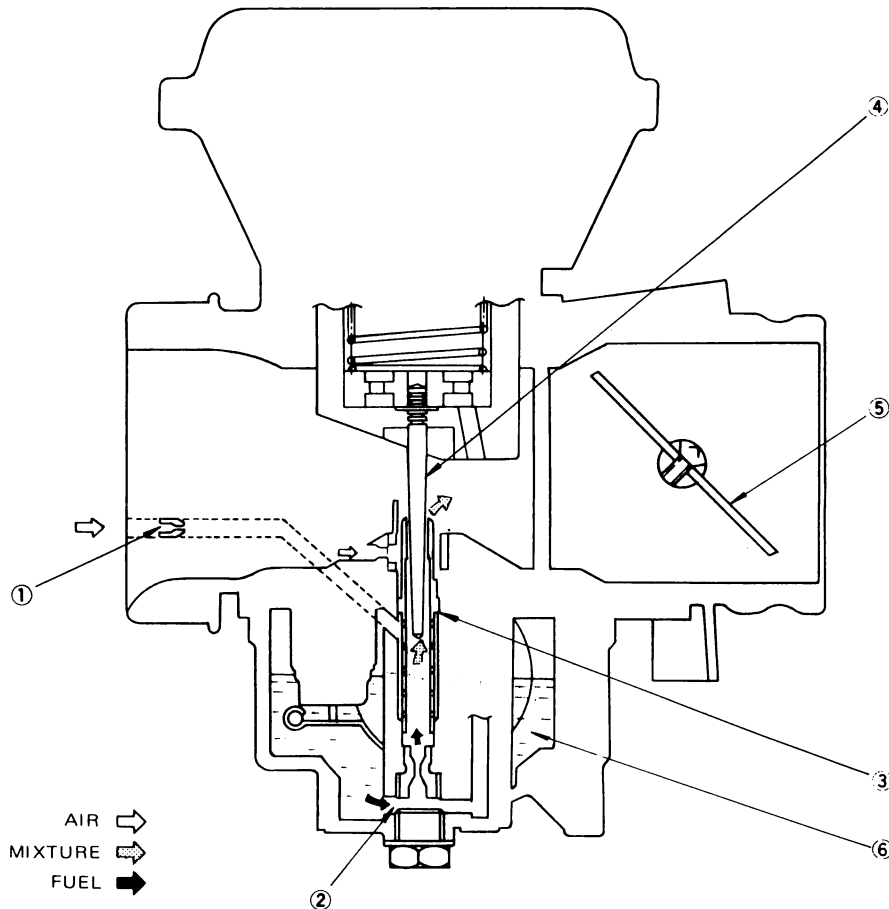


Compare this with diagrams of slide carburettor pilot systems, and it will be noted that there are few differences. The bypass outlet (6) and pilot outlet (7) have been moved to the top of the bore because the butterfly turns anti-clockwise and would obscure outlets at the bottom.



**Fig. 6.6 High speed operation – CD carburetors**

Compare with Fig. 5.2. The throttle butterfly (3) is now  $\frac{3}{4}$  open, and a much higher vacuum has been developed in the area beneath the rear of the piston valve. This vacuum effect has been transmitted via the vacuum port to the vacuum chamber; air beneath the diaphragm (1) is at atmospheric pressure and has lifted the piston valve assembly (2) until the pressures are in balance. As soon as venturi depression lessens, the piston valve will fall to compensate.



**Fig. 6.7 Main fuel system operation – CD carburetors**

Again, this bears direct comparison with the conventional slide types. Air enters the air jet (1) and passes to the emulsion tube where it is mixed with fuel from the main jet (2). At  $\frac{1}{4}$ – $\frac{3}{4}$  throttle, the needle jet (3) and jet needle (4) control the mixture volume, the needle and piston valve height being determined by engine vacuum in response to the throttle butterfly (5) setting. A conventional float arrangement (6) is employed.



### Stage 1: idle and low speed

1 Unless a single CD carburettor is fitted, which is relatively unusual, it is important to ensure that the instruments are correctly synchronised. It is normal practice to fit a single throttle stop screw, usually a knurled wheel, to adjust the idle speed of each instrument simultaneously. The spindle of each butterfly valve is interconnected, and provision is made for adjustment in relation to each butterfly and its neighbour. This is normally by means of a small adjuster screw and a locknut. This synchronisation adjuster screw will be found between the instruments, where the connecting spindles terminate in small interlocking brackets. The throttle stop screw is fitted either between the carburettors or at one end of the operating spindle, and if examined will be seen to control the setting of **all** the butterfly valves simultaneously.

2 The pilot mixture screw is fitted into the carburettor body, usually on the engine side of the mixing chamber. On many recent machines a small plastic limiter cap is pushed over the screw head to dissuade the owner from moving the screw by more than  $\frac{1}{2}$  turn or so. This is fine if it gives sufficient adjustment range, but it is often necessary to remove the cap to adjust the mixture correctly.

3 The various adjustment screws should be identified before proceeding any further. Again, if possible, have a workshop manual to hand, as this will contain a drawing or photographs showing the various screws and their positions, and may save much confusion for owners unfamiliar with their machines.

4 Set each of the pilot mixture screws to its recommended position. This is normally between  $\frac{1}{2}$  -  $1\frac{1}{2}$  turns out, meaning that the screws should be turned clockwise until they **just** seat, and then backed off by the appropriate amount. It should be noted that the limiter caps must be removed to permit this setting to be checked. When the screws are in their prescribed position, refit the caps in the mid-way position. This will give about  $\frac{1}{2}$  turn adjustment in each direction, and will normally be sufficient for intermediate settings, though for full tuning from scratch, the caps should be left off.

5 With the pilot mixture screws set up in this way, the engine should be thoroughly warmed up, preferably by riding the machine for a few miles. Twin cylinder or single cylinder machines with one carburettor can be checked and adjusted as follows:

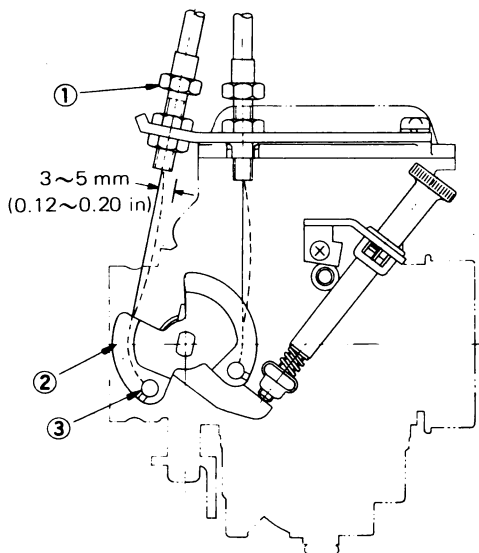


Fig. 6.8 Control cable and throttle stop adjustment (typical)

- |                           |                              |
|---------------------------|------------------------------|
| 1 Throttle cable adjuster | 3 Cable nipple               |
| 2 Pulley                  | 4 Throttle stop control knob |

6 Start the engine, and adjust the throttle stop screw until a slow idle speed is obtained. Now move the pilot mixture screw by  $\frac{1}{8}$  turn at a time, noting the effect that this has on the engine speed. Make a careful note of the amount by which the screw is moved. After a while, the continued movement of the screw will tend to cause the engine to slow and to run rather erratically. Stop adjustment at this point and return the screw to its former nominal setting.

7 Repeat the above checks, but this time move the screw in the opposite direction. By this method, it is possible to discover the small range of screw adjustment in which the engine will run reliably. The mixture screw can be set midway between the two extremes to give a reliable, even tickover. If necessary, make final fine adjustments to the idle speed by means of the throttle stop screw.

8 On twin-cylinder, twin-carburettor installations, it will be necessary to attend to the problems of synchronisation, or balancing carburettors which are out of balance will result in surprisingly rough running, and it is vitally important to ensure that this is correct. Where CD carburettors are employed, it is not really sufficient just to check that the two butterfly valves open together, as this does not necessarily mean that the piston/valve arrangements will do likewise. For this reason, it is recommended that vacuum gauges are used to check the depression in each inlet passage. For owners who wish to attempt adjustment by feel, the following procedure should be followed.

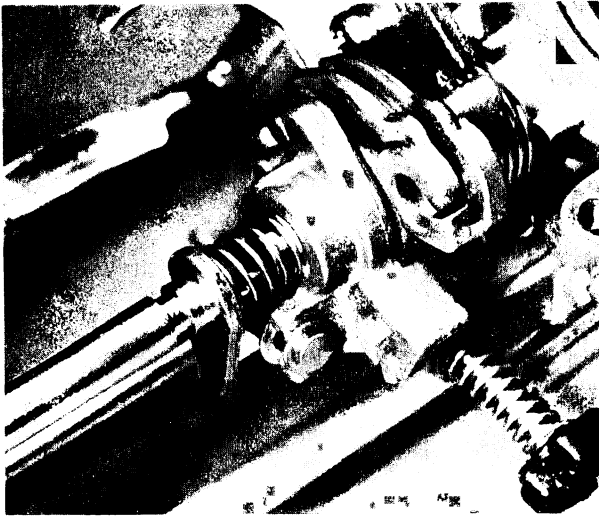
9 First, check visually the mechanical synchronisation of the butterfly valves as far as is possible. This will probably require the use of a torch and a mirror to enable one to peer down into the two instruments. It is normally just possible to see underneath the piston/valve assembly, but if necessary, these may be temporarily propped open.

10 Slacken off the throttle stop screw(s) and check that both butterfly valves are fully closed. Slowly turn the twist-grip until the valves begin to open. If all is well, this will happen simultaneously. Now open the twistgrip fully so that the butterfly disc can be viewed edge-on. Any discrepancy between the two should now be readily apparent, and the necessary adjustment made by way of the synchronising screw between the two instruments. This operation is rather delicate and must not be rushed. Take time and ensure that the two butterfly valves are aligned as accurately as possible. It is helpful to arrange the mirror so that it remains in a convenient position, leaving the hands free. This can be accomplished by sticking it in place with plasticine or Blu-tack.

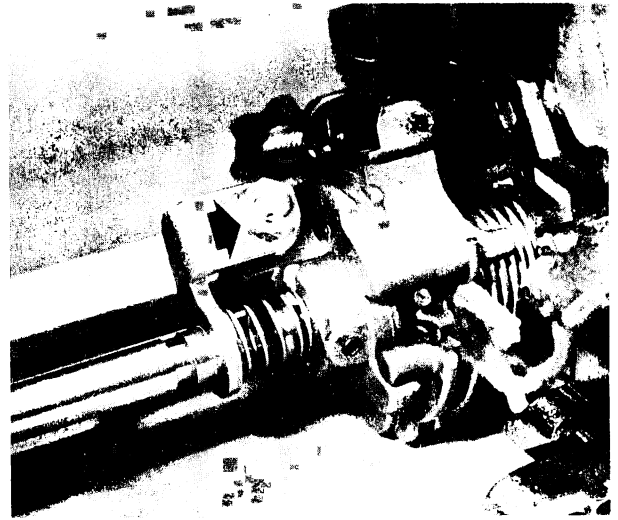
11 Having checked that the mechanical synchronisation is correct, remove one of the sparking plug caps and earth the high tension lead. Remove the sparking plug from the isolated cylinder so that when the engine is started its functioning cylinder has less resistance to overcome. Start the engine, keeping it running by judicious use of the throttle twistgrip whilst the common throttle stop screw is set to maintain a reliable tickover. The engine will not run particularly smoothly with one cylinder isolated, but this is of no great importance at this stage.

12 With the engine idling at the slowest practicable speed, make exploratory pilot mixture screw adjustments on the functioning carburettor. The screw should be turned by about  $\frac{1}{8}$  turn at a time and its effect on the idle speed and regularity noted, as described earlier in the case of single carburettor installations. By this method the best pilot mixture setting can be identified as that which produces the fastest and most even idle speed. If necessary, reduce the idle speed by means of the common throttle stop screw and repeat the test until the optimum setting is found. Make a note of the engine speed shown on the tachometer, where this is fitted, then stop the engine.

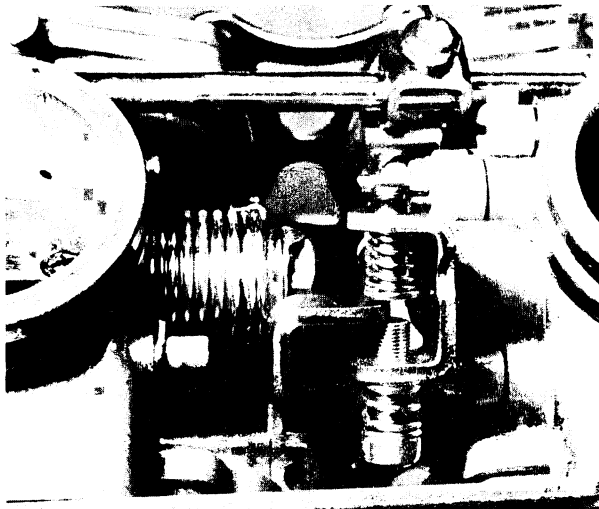
13 Refit the sparking plug and lead, and then remove the other plug, earthing its lead as before. Re-start the engine. This time, make **no** adjustment to the throttle stop screw, as this will have an effect on the cylinder which has just been set up. Instead, idle speed adjustment should now be made by means of the



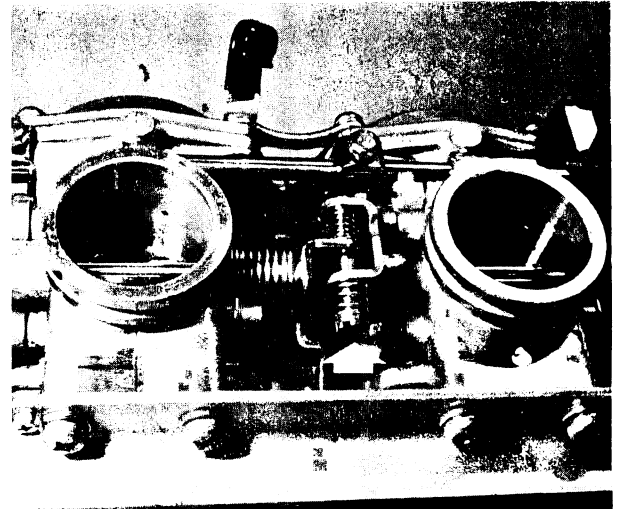
6.3 A common, or master, throttle stop control is fitted to multiple carburettor installations



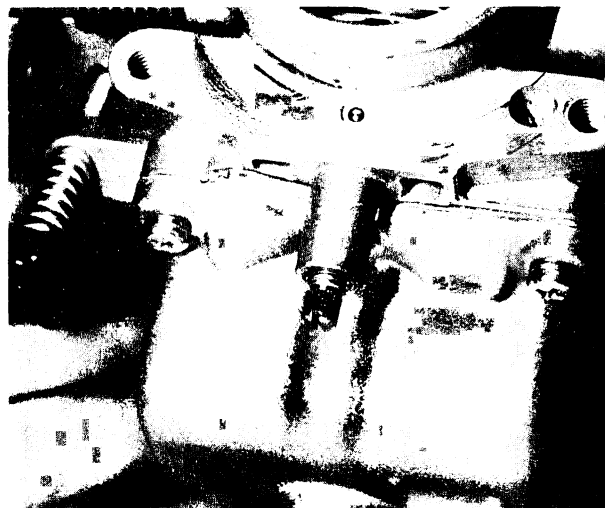
6.4 Synchronising screw is paint-marked at factory after adjustment



6.5 Synchronisation is corrected by moving one of the linkage brackets in relation to the other. The adjusting screw is at the bottom and is balanced by a sprung plunger at the top



6.6 Yamaha XS750 carburettor bank removed to show position of synchronising screws. As may be appreciated, these can be difficult to reach in situ



6.7 Pilot mixture screws can be almost inaccessible. They are normally fitted vertically from the underside of the instrument(s)

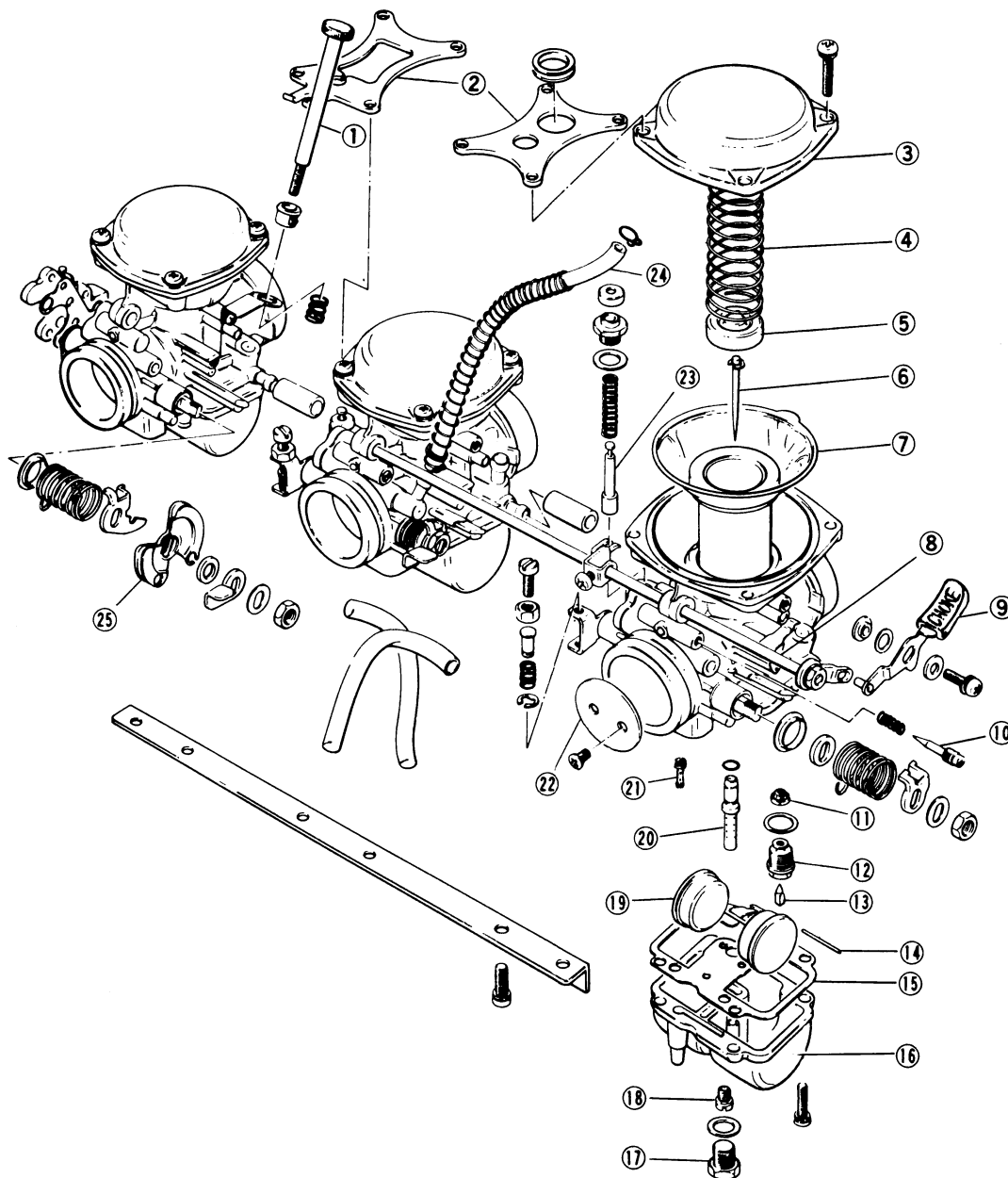


Fig. 6.9 Typical multiple CD arrangement

- 1 Master throttle stop control
- 2 Connecting bracket
- 3 Vacuum chamber top
- 4 Return spring
- 5 Jet needle retainer
- 6 Jet needle and clip
- 7 Diaphragm and piston valve
- 8 Cold-start shaft
- 9 Cold-start lever

- 10 Pilot mixture screw
- 11 Fuel filter
- 12 Float valve seat
- 13 Float needle valve
- 14 Float pivot pin
- 15 Gasket
- 16 Float bowl
- 17 Drain plug

- 18 Main jet
- 19 Float
- 20 Needle jet
- 21 Pilot jet
- 22 Throttle butterfly
- 23 Cold start plunger
- 24 Fuel pipe
- 25 Throttle pulley

synchronising screw which is fitted between the two carburettors.

14 If the initial setting-up of the two butterfly valves was accurate, any further adjustment should be minimal. Find the optimum pilot mixture screw setting as described above, and note the engine speed on the tachometer. If no tachometer is fitted, or available as a test instrument, this can only be approximated, which is far from satisfactory. Ideally, the idle speeds of each cylinder should now be equal, but if necessary make any minor adjustment to the synchronising screw to obtain a similar speed on both cylinders.

15 Refit the sparking plug and lead, and start the engine, this time with both cylinders functioning. The idle speed will almost certainly be too high at this stage, and should be reduced by means of the shared throttle stop screw. Open and close the twistgrip a few times, and then allow the engine to settle down to what is, it is hoped, a slow, regular idle.

16 With the engine idling, place a hand over the end of each silencer, and note the exhaust gas pulses. If the carburettors have been set up correctly, a regular pulse will appear at each silencer in turn, indicating that each cylinder is running evenly, and at a similar speed. If, on the other hand, one cylinder seems to be pulling strongly and regularly, and the other is firing spasmodically and weakly, it indicates that one cylinder is trying to run faster than the other. As this is plainly impossible, it means that the slower cylinder is being carried by the other, and imbalance exists between the two. To correct this, make **minute** adjustments to the synchronising screw until a similar pressure exists at each silencer end. Do not be put off by occasional misfires at either silencer. This is almost inevitable with most engines. The important factor is to obtain a balance of pressure between the two. If the engine is sound and well tuned, and the carburettors undamaged, this should be feasible.

17 It will be seen that this method of tuning is really something of a technique, and as such, must be mastered if reliable results are to be expected. If at the end of the sequence the machine is still running badly, the best thing to do is to go indoors, have a coffee or tea break, and then start again from scratch. Ultimately, it is possible to obtain good results by this method, but patience and practice are necessary in the absence of tuning aids. There is one other technique which can be used to good effect at this stage, and this involves the use of a length of plastic tubing which can be employed to listen to the intake hiss at the mouth of each carburettor.

18 For those owners who are daunted by, and dubious of, the foregoing, the only course of action is to employ vacuum gauges. This will eliminate all guesswork and ensure accurate synchronisation but only at the cost of some financial expenditure. Whilst vacuum gauges can be considered a useful luxury for owners of twin-cylinder machines, this is not true for those who have three or more carburettors to tune. For them it becomes essential.

19 On machines having three or more cylinders, and a corresponding number of carburettors any form of manual synchronisation or pilot mixture adjustment is effectively impossible. Although it might be possible to achieve some degree of satisfactory running, the time involved and poor accuracy rule it out. Many multi-cylinder machines are extremely sensitive to carburettor maladjustment, and it has even been known to give rise to expensive knocking noises by producing exaggerated backlash in the primary drive.

20 To facilitate regular, accurate servicing, an appropriate vacuum gauge set should be considered essential. There are a number of possibilities here, and these are discussed at greater length in Chapter 11. Adjustment of the pilot mixture becomes a problem with multi-cylinder machines, and in many cases, the manufacturer seems to side-step the inevitability of wear occurring by stressing that the mixture is set at the factory and should not be tampered with. This sort of statement is directed at the retailer, and no mixture setting is quoted, so when the engine and carburettors become slightly worn, the owner is faced with an awkward problem.

21 With no factory information to act as a tuning basis, the

owner can either ignore any developed low speed running problems or try to rectify them by trial and error. The only economic alternative is to obtain a device known as Colortune 500, which will allow the mixture strength to be diagnosed with great accuracy, and any adjustment made accordingly. This device and its uses are discussed in detail in Chapter 11.

22 Before attending to idle speed or pilot mixture adjustment, the carburettors must be synchronised with the aid of vacuum gauges. The principle can be applied to any installation of two or more instruments. Start by identifying the synchronising screws which will be found between each carburettor on the connecting linkage. On twin carburettors, only one synchronising screw is fitted, triple carburettors having two, and so on. Work out on what these screws have an effect before attempting to balance the carburettors. On the Yamaha XS750, for example, the screws regulate the outer instruments to the central carburettor, and in consequence, the two outer carburettors are balanced in relation to the centre instrument. On other machines, one outer instrument in the 'master' carburettor, the remainder being balanced to this. Reference to the appropriate workshop manual will be of considerable help here.

23 On some machines, the proximity of the fuel tank will make adjustment rather difficult, and to obviate this problem, a length or lengths of plastic fuel pipe can be used to enable the tank to be mounted remotely during the tuning operation. The carburettors will each have a vacuum gauge take-off point on the engine side of the carburettor. In some cases this takes the form of a blanking screw on each instrument, although some machines have a suitable stub incorporated in the intake pipe or adaptor.

24 Connect up the vacuum gauge set, noting that it may be necessary to calibrate each gauge to one carburettor before the test begins. As always, the check should be carried out with an engine at normal running temperature. Start the engine, and note the effect on the mercury columns or gauge needles. A certain amount of pulsing is normally found, and most gauges can be adjusted to damp this out, either by means of a clamp on the connecting tubes or by a screw on each gauge. The object is to restrict the fluttering of the gauge or column, without impairing its ability to react to sudden throttle openings.

25 Once the equipment is correctly set up, the adjustment is quite simple. Note the reading shown on each gauge, and compare this with that shown in the manufacturers' specifications, where available. The important aspect of this test is to obtain an equal reading for each instrument. Make any appropriate adjustment to the synchronising screws. Open and close the throttle twistgrip a few times, then let the engine settle down before re-checking the readings. When the instruments are balanced satisfactorily, remove the vacuum gauges, refit the blanking plugs and the test is complete. If the engine tends to idle too fast, it may now be slowed down by adjusting the throttle stop screw which controls the butterfly valves of all carburettors simultaneously.

26 As mentioned previously, pilot mixture adjustment can prove very difficult without some means of checking the mixture strength. It is not practicable to set up each cylinder individually, because a multicylinder engine will not run properly without all its cylinders functioning. Unless a Colortune is available, the owner can do little more than set the mixture screws at the prescribed number of turns out. Where this information is not available, or is described by the manufacturer as 'preset', the pilot mixture screws should be left untouched.

### *Stage 2: intermediate and high speeds*

1 The intermediate and high speed areas can be considered to correspond approximately with  $\frac{1}{4}$  throttle to full throttle range of the slide carburettor. In the case of CD instruments, the low speed circuits will have lessened in effect, and fuel will be drawn from the needle and needle jet. The piston/valve assembly will have started to respond to various engine requirements. Ultimately, at high speed, the butterfly valve will be fully open, as will the piston/valve, and operating conditions will have become identical to the slide carburettor at full throttle.

2 The nature of the CD instrument is such that it is difficult to establish whether or not the piston/valve arrangement is behaving normally. It will be appreciated that to check the degree of piston opening with the engine under load in top gear at 60 mph poses a number of problems. Tuning must, therefore, take the form of a fault diagnosis sequence.

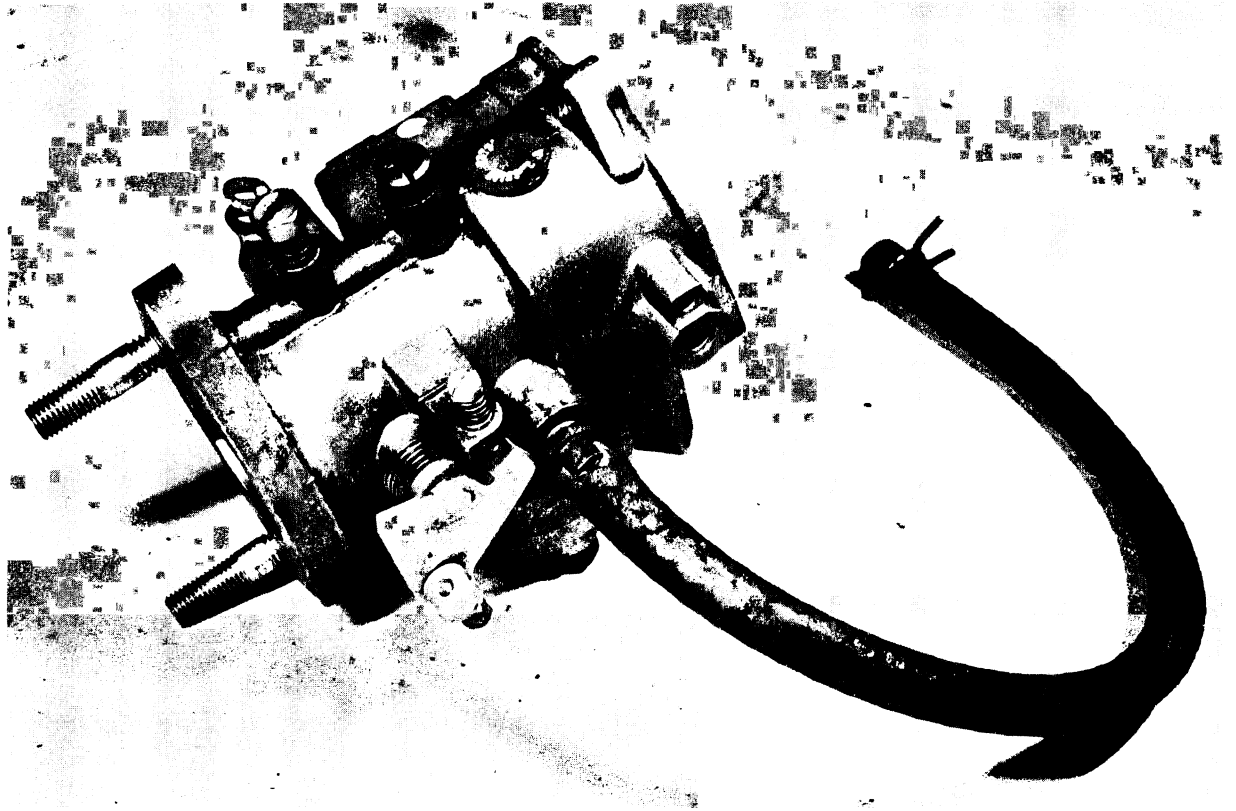
3 It must be stressed that once the factors governing the piston's behaviour have been established and the carburettor designed accordingly, no appreciable change to these components is normally required. Wear will, of course, cause indifferent operation, and this can be rectified in the course of an overhaul. It is important that everything functions as intended.

4 If the machine is running badly or using too much fuel, some indication of the nature of the fault may be gleaned from the symptoms exhibited. To this end, reference should be made to the fault diagnosis tables. When the likely cause has been identified, the carburettor(s) can be dismantled and overhauled, paying particular attention to the component(s) suspected of

malfunction.

5 When a Colortune 500 is available, a number of checks can be made to ensure that the carburettors are providing the correct mixture through the intermediate range. These are dealt with in detail in Chapter 11.

6 At high speeds, the carburettor throat is virtually unrestricted, and the needle and needle jet will have no appreciable effect on the rate of fuel flowing through the main jet. It will be appreciated that the choke size of the carburettor and the main jet size are now the two factors which control the mixture strength and engine speed. As the choke size cannot be altered unless a new carburettor is fitted, the main jet size is the only normal means of adjustment. The method of checking its suitability is the same as that given for checking main jet operation on fixed jet carburettors. A high speed run is made, the engine is stopped quickly, and the sparking plug colour checked as an indicator of mixture strength. For full details, refer to Section 3 of Chapter 4.



One of the few fixed-jet motorcycle carburettors – Harley Davidson's Bendix

## Chapter 7 The Fixed Venturi Carburettor

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If we were to take a random selection of modern motorcycles, it is likely that more than 90% of them would be fitted with variable venturi carburettors – either the ubiquitous slide instrument or the increasingly popular CD type. It would be reasonable to conclude from this that the fixed venturi (or fixed jet) carburettor was unsuitable for motorcycle use, though predominant in car applications.

This may be true up to a point, but in fact the absence of modern fixed venturi motorcycle carburettors stems from a divergence in design thinking in the early days of motorcycling. Quite simply, the variable venturi carburettor proved more effective in the early days and thus was developed at the expense of the embryonic fixed venturi type. Had the early fixed venturi designs proved more successful than the slide type, it is likely that these instruments would be predominant today.

If we define the fixed venturi type it becomes clear that the familiar slide and CD types are not quite as simple as they may appear at first sight.

In a fixed venturi instrument, we find that, as the name implies, the venturi size remains unchanged throughout the operating range. The flow of mixture to the engine is controlled by a butterfly valve at the engine side of the carburettor. A number of jets are arranged in a manner that causes them to discharge a metered flow of fuel at a given throttle setting, the fuel being drawn through the jet by the degree of depression in the venturi. As the throttle opens, the effect of the first jet lessens and at the same time the next fuel circuit is brought into operation by the changed characteristics of the air flow through the carburettor.

It will be appreciated that this is no more than a logical development of our theoretical carburettor outlined at the beginning of this book. As one jet can only provide the correct mixture ratio over a very small range of throttle openings, it is necessary to introduce additional fuel systems and jets to take over as each successive system loses effect. In the simplest fixed venturi carburettors, a low speed and a high speed system are employed, usually augmented by an accelerator pump to smooth the transition from one to the other.

Increased sophistication can be obtained by incorporating more jets, drillings and spray tubes, and within reason, the more jets and orifices provided, the smoother and more accurate the mixture control becomes. On the debit side, the more complex and fine the construction of the carburettor, the less robust and reliable it becomes.

An interesting example of the multi-jet fixed venturi carburettor was chosen by Velocette when they launched their LE machine in October 1948. In keeping with the watch-like complexity of the rest of the engine and transmission, a tiny fixed venturi instrument was fitted. This carburettor was in essence a scaled-down version of contemporary car carburettors. The mixing chamber was in two halves, these being drilled to accept the jets and spray tubes. The upper half of the mixing chamber was incorporated in the underside of the main venturi and housed three spray tubes leading into the tiny main bore of the venturi. The lower part of the mixing chamber was an extension of the separate float chamber, and was drilled to accept a main fuel jet, a starting jet, a compensating fuel jet and a pilot bridging fuel jet.

All this resulted in a small but complicated instrument. The carburettor did work, but suffered from problems with the numerous tiny jets and passages becoming obstructed by water or dirt in the fuel, and soon attained a poor reputation amongst the traditionally conservative owners, who were probably rather frightened by all the complexity.

In desperation, the production of this carburettor was given to Amal, in the hope that something could be salvaged from the poor design. Production continued for a short time, but the numerous drawbacks were never successfully overcome.

It is significant to note that the Amal LAS84 carburettor was dropped quite quickly, and a scaled-down version of the Amal Monobloc, the Type 363 was introduced to replace it. This story typifies the numerous brief forays into fixed venturi carburettors by the carburettor and motorcycle manufacturers, and serves to underline how simplicity has prevailed to date.

A notable exception to this general rule of avoidance is Harley-Davidson, who has traditionally employed simple fixed venturi carburettors. There are three makes involved, and these will be discussed in greater detail later. Another machine to use a fixed venturi carburettor was Suzuki's ill-fated RE 5. This used a compound or twin-choke instrument, similar to the Weber instruments found on many cars. In this arrangement, two parallel chokes or venturis are employed. At low engine speeds, the primary choke operates in the normal way, but as engine speed rises the second choke comes into operation. This arrangement allows much greater flexibility than a single venturi, but without the disadvantages of a large number of jets and bleeds. If fixed jet carburettors ever find favour in motorcycle applications, it is likely that this type of instrument will be chosen.

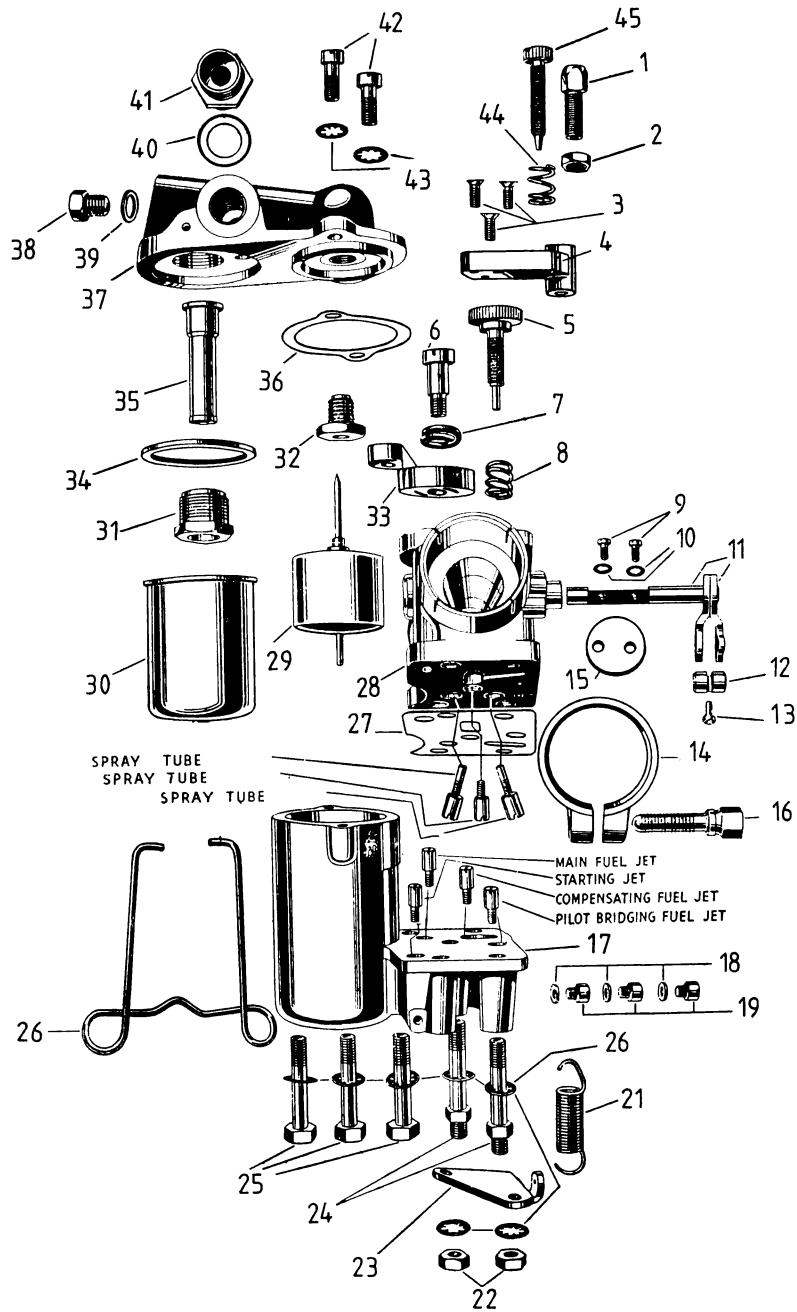


Fig. 7.1. The Amal LAS 84 fixed-jet carburettor

- |                                  |                                     |                                   |
|----------------------------------|-------------------------------------|-----------------------------------|
| 1 Cable adjuster                 | 16 Clamp screw                      | 31 Filter element sleeve          |
| 2 Locknut                        | 17 Mixing chamber body – lower half | 32 Float valve seat               |
| 3 Screws                         | 18 Blanking plug washers            | 33 Starting lever                 |
| 4 Cable adjuster fixing plate    | 19 Blanking plugs                   | 34 Seal                           |
| 5 Pilot air screw                | 20 Shakeproof washers               | 35 Filter element                 |
| 6 Starting lever pivot screw     | 21 Throttle return spring           | 36 Gasket                         |
| 7 Double spring washer           | 22 Nuts                             | 37 Float chamber cover            |
| 8 Adjuster screw friction spring | 23 Throttle spring anchor plate     | 38 Plug screw                     |
| 9 Throttle butterfly screws      | 24 Mixing chamber bolts             | 39 Sealing washer                 |
| 10 Washers                       | 25 Mixing chamber bolts             | 40 Sealing washer                 |
| 11 Throttle spindle              | 26 Filter cup retaining clip        | 41 Fuel inlet connection          |
| 12 Trunnion                      | 27 Gasket                           | 42 Screws                         |
| 13 Cable nipple                  | 28 Mixing chamber body – upper half | 43 Shakeproof washers             |
| 14 Mounting clamp                | 29 Float and needle assembly        | 44 Adjuster screw friction spring |
| 15 Throttle butterfly plate      | 30 Filter cup                       | 45 Throttle stop screw            |



# Chapter 8 Tuning Fixed-jet Carburetors

## Contents

Preliminary checks . . . . .	1	Tuning procedures . . . . .	4
Checking the float height – Bendix and Keihin . . . . .	2	General running problems – fixed venturi carburetors . . . . .	5
Fuel diaphragm – Tillotson carburetors . . . . .	3		

### 1 Preliminary checks

In this Chapter, attention will be given to the three types of fixed venturi instrument in common use today. These are the Tillotson, Bendix and Keihin carburetors fitted by Harley-Davidson. The three types are of basically similar construction, and are very simply jetted. All comprise a roughly tubular main body beneath which is the Tillotson's diaphragm chamber or the float chamber in the case of the remaining two devices.

In each case, the throttle operates a simple butterfly valve arrangement mounted at the engine side of the body, with a similar arrangement on the atmospheric side employed to facilitate cold starting. All three make use of accelerator pumps which provide a preset measure of fuel that is injected into the main choke when the throttle is opened. This provides a richened mixture for a clean transition from intermediate to high speed operation.

Before tuning is undertaken, make sure that all other engine adjustments such as ignition timing and valve clearances are set correctly. The air filter should be cleaned, or if necessary, renewed. As with all carburettor adjustment procedures, make sure that the engine is at normal operating temperature before work commences.

### 2 Checking the float height – Bendix and Keihin

If the carburettor has suddenly developed a serious malfunction, or has been running excessively rich, the float height should be checked before the tuning sequence commences. To facilitate this check it will be necessary to remove the carburettor from the machine, and to release the float bowl. Invert the carburettor so that the float lies in the closed position. In the case of the Bendix instrument, the float should be  $\frac{3}{16}$  in away from the carburettor gasket face. This can be conveniently checked by inserting a suitable twist drill shank in the gap and checking the clearance. Adjustment can be made by bending the small tang which operates the valve needle, after releasing the float assembly by displacing its pivot pin.

In the case of Keihin instruments, two settings require checking. First, check the fully closed position by inverting the carburettor as described above. Measure the distance between the gasket face and the underside of the float. This should be 0.55 – 0.63 in (14 – 16 mm). Now turn the carburettor up the right way and repeat the measurement. This time it should be 1.10 – 1.18 in (28 – 30 mm). The Keihin float has a normal operating tang plus a stopper tang. Both can be bent to the required position after the float has been removed.

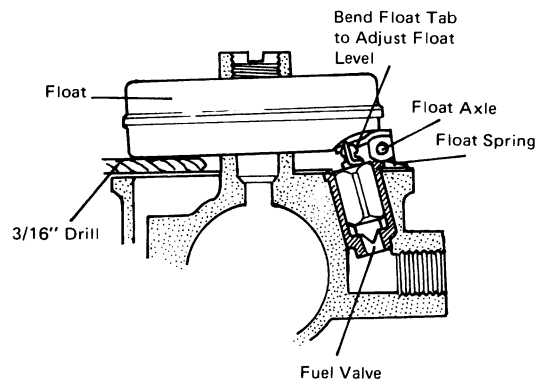


Fig. 8.1 Checking the float height – Bendix carburettor

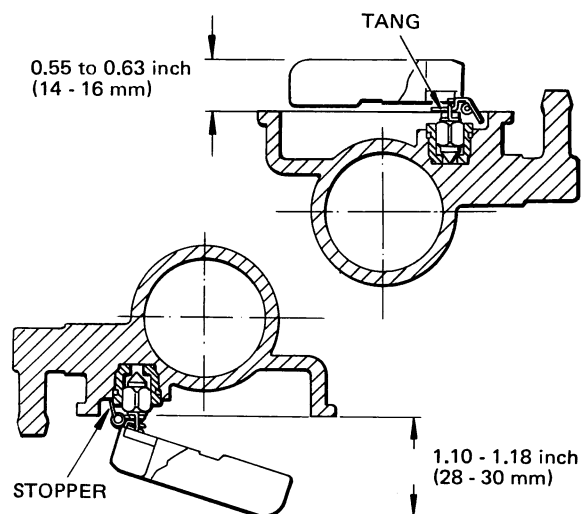


Fig. 8.2 Checking the float height – Keihin carburettor

### 3 Fuel diaphragm – Tillotson carburettors

The Tillotson does not use a conventional float system, but instead employs a diaphragm and chamber in which a constant fuel level is maintained. This does not normally warrant investigation as part of the tuning procedure, but if problems of flooding have been evident, the diaphragm should be removed and checked for damage or incorrect assembly. See Chapter 9 for further details.

### 4 Tuning procedures

#### *Checking the main jet size*

1 The main jet controls the mixture strength at large throttle openings, and is best checked by making a test run under appropriate conditions. Select a suitable quiet stretch of road, preferably slightly uphill, and make a fairly fast full throttle run. At the end of the test run, disengage the clutch and stop the engine, allowing the machine to coast to a halt.

2 Remove the sparking plugs, and check the appearance of the electrodes. If the main jet is of the correct size, the electrodes will be an even greyish-tan colour, indicating the correct mixture strength. If the plugs appear black and sooty, the main jet will be too large, and the test should be repeated using progressively smaller jets until the correct colour is obtained. Too small a jet will give a weak mixture, resulting in burnt electrodes with a whitish oxide deposit. It is this condition which is most harmful, and must be rectified quickly before engine damage is caused. If in any doubt, always err on the side of a rich mixture, rather than one which may be slightly weak.

#### *Low and intermediate mixture screw settings – Tillotson carburettors*

1 The Tillotson instruments have two mixture control screws. The low speed mixture screw has a large knurled head and will be found on the top of the carburettor, near the engine mounting flange. The intermediate mixture screw has a smaller head and is screwed into the side of the carburettor body, about half way along its length. Start by setting each screw as follows. Turn the screw clockwise until it seats lightly against the carburettor casting, then carefully back it off by  $\frac{7}{8}$  of one turn.

2 Start the engine, and set the throttle stop screw so that it gives the slowest, even idle speed possible. Move the low speed screw in either direction by about  $\frac{1}{8}$  turn at a time, noting the effect on the idle speed. There will be noted two points at which the engine will start to falter due to excessive weakness or richness. At a point between these extremes, a regular, even tickover should be obtained, and the screw should be set here.

3 Adjust the throttle stop screw until the engine runs at about 2000 rpm. Repeat the adjustment sequence, this time with the intermediate mixture screw.

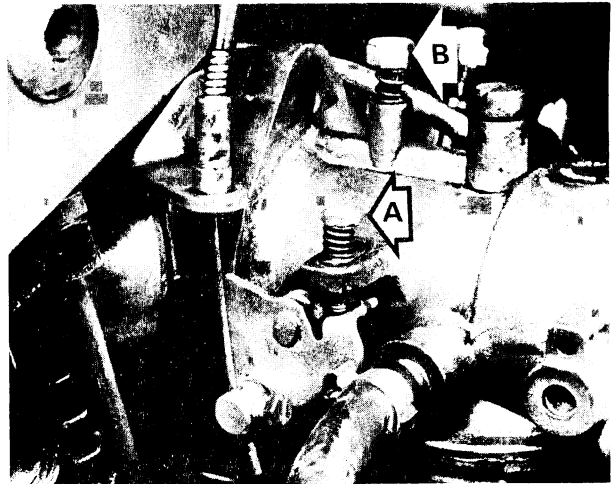
4 Turn the intermediate mixture screw in each direction until a point is reached where the engine runs smoothly and evenly with no sign of either mis-firing or hunting, then turn it anti-clockwise by a further  $\frac{1}{8}$  turn.

After completing the mixture screw adjustments, slow the tickover speed down to 1000 rpm or lower by means of the throttle stop screw.

#### *Mixture screw setting – Bendix and Keihin*

1 The pilot mixture screws on both Keihin and Bendix types are located on the top of the instrument, close to the mounting flange. Start by screwing the mixture screw clockwise until it just seats, and then backing it off by  $1\frac{1}{2}$  turns. With the throttle stop screw, set the idle speed at 700 – 900 rpm.

2 Make exploratory adjustments of the mixture screw, turning it  $\frac{1}{8}$ -turn at a time, until the optimum idle speed is found. Check that the engine accelerates smoothly from idle as the twistgrip starts to open. When a satisfactory setting has been found, reset the throttle stop screw to give a 700 – 900 rpm idle speed, if required.



8.1 Throttle stop (A) and mixture screws (B) – Bendix (Keihin arrangement is similar)

### 5 General running problems – fixed venturi carburettors

Assuming that the pre-set jet sizes and general condition of the carburettor are in order, the adjustments shown in the preceding sections should result in smooth operation at all speeds. Further running problems are likely to be attributable to wear or damage in the instrument, rather than poor adjustment or jet sizing.

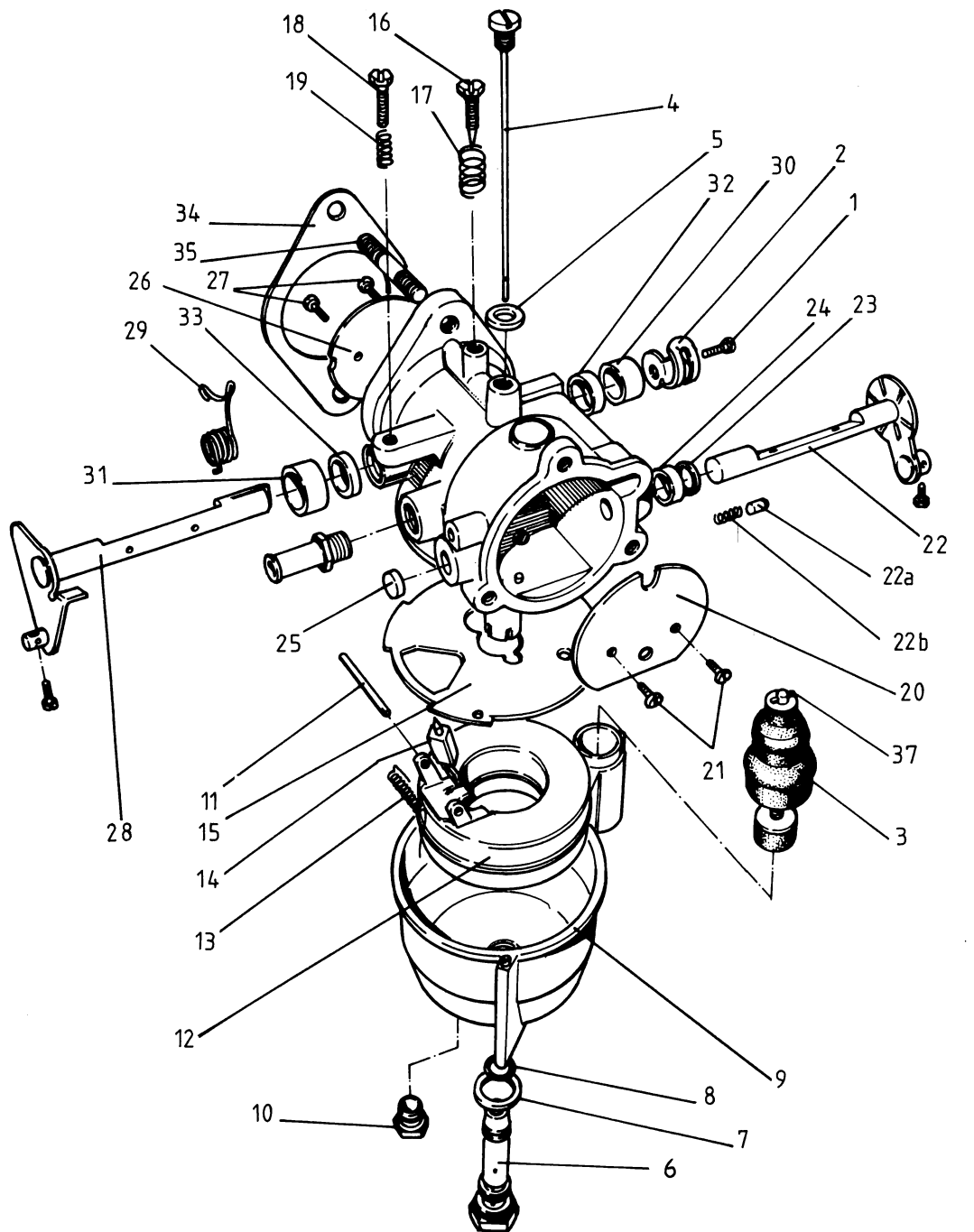
Problems are likely to be encountered where the accelerator pump is worn or damaged, as this is largely responsible for a smooth transition from the low to intermediate settings through to the main jet operation at large throttle openings. Accelerator pump operation cannot easily be checked at home, and all that can reasonably be done is to ensure that a consistent and steady flow of fuel is present when the twistgrip is opened. If the pump's operation seems erratic, reference should be made to Chapter 9 for overhaul details.

Generally, erratic running is likely to be caused by air leakage into the instrument. This may be by way of the throttle valve pivots, and if this is the case, boring and bushing the carburettor body or carburettor renewal will be necessary before the machine can be persuaded to function reliably. Another possible source of air leakage is the Welch plugs which are used to seal off passages in the carburettor body. These can often be cured by judicious use of a fuel resistant sealing compound, but it must be noted that the silicon RTV sealants are not suitable for this job.

Dirt, and particularly, water, in the fuel system can give rise to infuriatingly unpredictable running problems, as it can spasmodically obstruct the various passages only to clear again as it moves through them. The only cure is to dismantle the entire system for careful cleaning. The fuel tank should be flushed out and fresh petrol used.

On older instruments, the threads which carry the mixture screw(s) may eventually allow air leaks to develop. This can be difficult to resolve, but some thin PTFE tape wrapped around the threads may prove successful.

On the earliest models equipped with Keihin instruments, occasional problems were encountered due to heat transference from the engine back to the carburettor. The cure here is to fit a heat sink block between the carburettor and inlet mounting. The block and the necessary extended studs are available from Harley-Davidson dealers.



**Fig. 8.3 Bendix 16P12 fixed-jet carburettor**

- |                                |                               |                                 |
|--------------------------------|-------------------------------|---------------------------------|
| 1 Accelerator pump lever screw | 14 Float valve needle         | 25 Choke shaft cup plug         |
| 2 Accelerator pump lever       | 15 Gasket                     | 26 Throttle disc                |
| 3 Accelerator pump             | 16 Idle mixture needle        | 27 Throttle disc screw - 2 off  |
| 4 Idle tube                    | 17 Idle mixture needle spring | 28 Throttle shaft and lever     |
| 5 Idle tube gasket             | 18 Throttle stop screw        | 29 Throttle shaft spring        |
| 6 Main jet and tube assembly   | 19 Throttle stop screw spring | 30 Throttle shaft seal retainer |
| 7 Fibre washer                 | 20 Choke disc                 | 31 Throttle shaft seal retainer |
| 8 O-ring                       | 21 Choke disc screw - 2 off   | 32 Throttle shaft seal          |
| 9 Float bowl                   | 22 Choke shaft and lever      | 33 Throttle shaft seal          |
| 10 Float bowl drain plug       | 22A Plunger                   | 34 Manifold gasket              |
| 11 Float pivot pin             | 22B Spring                    | 35 Manifold stud - 2 off        |
| 12 Float assembly              | 23 Choke shaft seal retainer  | 37 Accelerator pump shaft pin   |
| 13 Float spring                | 24 Choke seal shaft           |                                 |

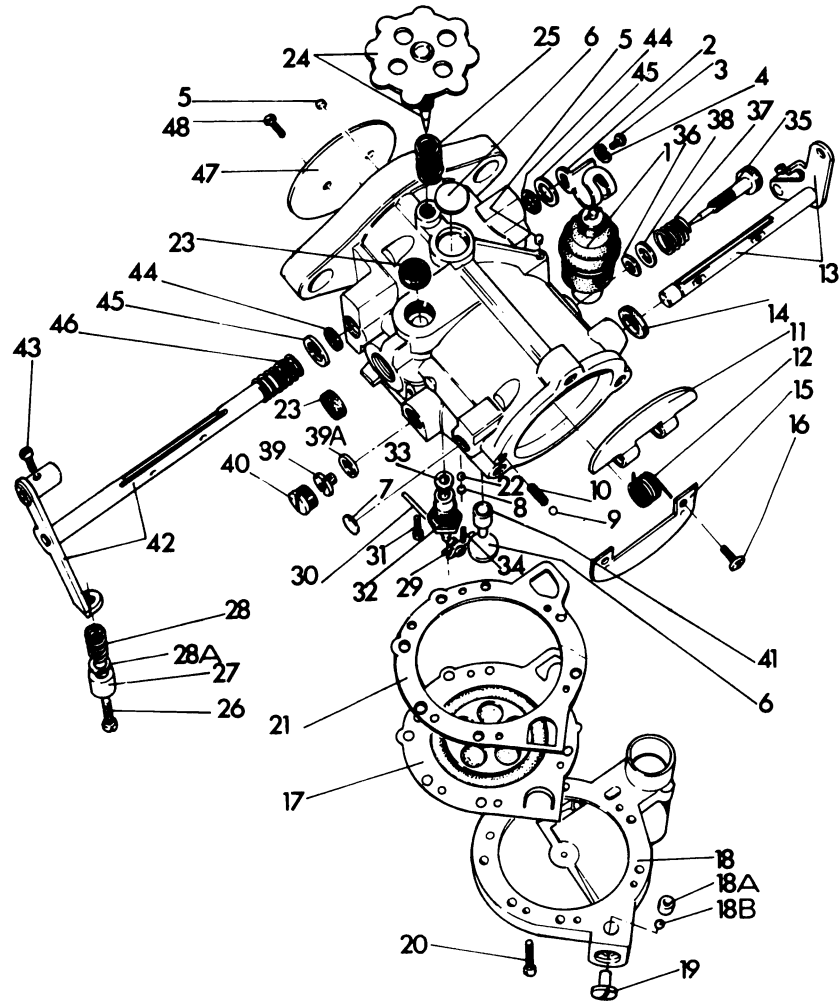


Fig. 8.4 Tillotson HD fixed-jet carburettor

- |   |   |
|---|---|
| 1 Accelerator pump                        | 25 Idle adjustment screw spring         |
| 2 Accelerator pump lever                  | 26 Throttle stop screw                  |
| 3 Accelerator pump screw                  | 27 Throttle stop screw cup              |
| 4 Accelerator pump lever screw lockwasher | 28 Throttle stop screw spring           |
| 5 Channel plug - 2 off                    | 28A Throttle stop screw spring washer   |
| 6 Welch plug                              | 29 Inlet control lever                  |
| 7 Welch plug                              | 30 Inlet control lever pin              |
| 8 Welch plug                              | 31 Inlet control lever screw            |
| 9 Choke shaft friction ball               | 32 Inlet needle and seat                |
| 10 Choke shaft friction spring            | 33 Inlet needle seat gasket             |
| 11 Choke shutter (top)                    | 34 Inlet control lever tension spring   |
| 12 Choke shutter spring                   | 35 Intermediate adjusting screw         |
| 13 Choke shaft assembly                   | 36 Intermediate adjusting screw packing |
| 14 Choke shaft dust seal                  | 37 Intermediate adjusting screw spring  |
| 15 Choke shutter (bottom)                 | 38 Intermediate adjusting screw washer  |
| 16 Choke shutter screws                   | 39 Main jet                             |
| 17 Diaphragm                              | 39A Main jet gasket                     |
| 18 Cover                                  | 40 Main jet plug screw                  |
| 18A Accelerator pump check ball retainer  | 41 Main nozzle check valve              |
| 18B Accelerator pump check ball           | 42 Throttle shaft assembly              |
| 19 Diaphragm cover plug screw             | 43 Throttle lever wire block screw      |
| 20 Diaphragm cover screws - 6 off         | 44 Dust seal - 2 off                    |
| 21 Diaphragm cover gasket                 | 45 Washer - 2 off                       |
| 22 Economiser check ball                  | 46 Throttle shaft spring                |
| 23 Fuel filter screen - 2 off             | 47 Throttle shutter                     |
| 24 Idle adjustment screw                  | 48 Throttle shutter screws              |

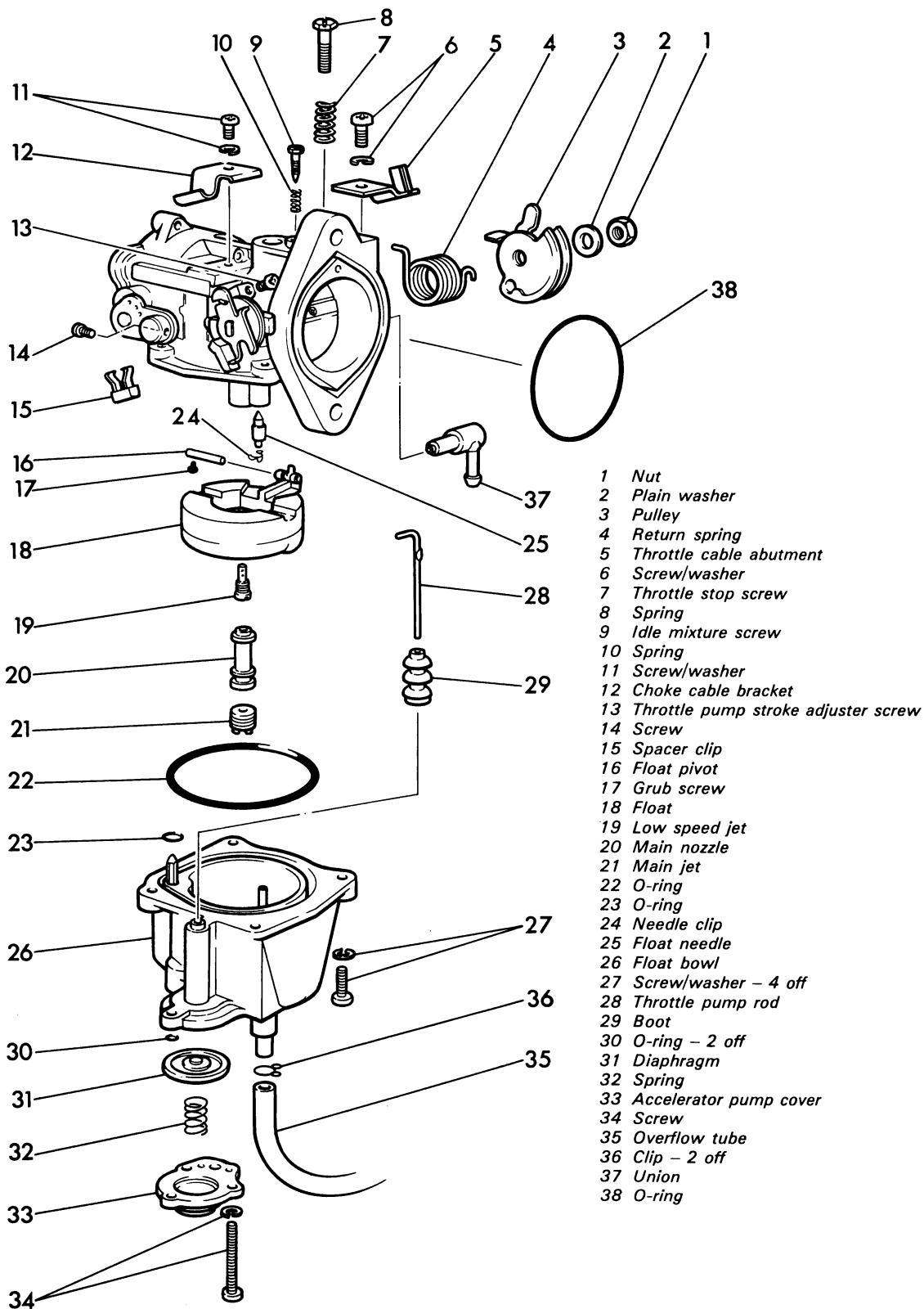


Fig. 8.5 Keihin fixed-jet carburettor

# Chapter 9 Carburettor Overhaul

## Contents

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Dismantling CD carburettors . . . . .	4		

## 1 Preliminary checks

At some time during the life of every motorcycle, the carburettor(s) are removed and dismantled. This is almost invariably because something seems to be wrong with them because the machine refuses to run properly. Often, the carburettor is not to blame; there being several other factors which can cause uneven running, notably ignition faults. At the risk of becoming repetitive, it should be stressed that all engine settings and adjustments must be attended to before blame is directed at the carburettor.

Of equal importance to the above is the need to establish the nature of the problem before reaching for the toolbox. Ride the machine on a quiet road where there are few distractions, and try to decide what might be causing the problem. It is essential to remember that there are only two possible carburation problems; excessive richness and excessive weakness. These may appear at any part of the throttle range, and thus can usually be traced to a particular component. The various stages of operation do overlap, of course, but it will be obvious, for instance, that if the machine will not idle but runs well at all other speeds, the main jet cannot be the prime suspect.

Some carburettor faults are quite subtle, and some experimental renewal of parts can occasionally be the only course of action. In general, the following sequence should be followed in the event of a fault becoming apparent.

- A: Check all adjustments and settings other than those of carburation. Road-test and note any change.
- B: Tune and synchronise the carburettors.
- C: Refer to the fault diagnosis tables, and road test the machine to isolate the likely cause.
- D: Dismantle, clean and overhaul the carburettors.

There is a traditional adage amongst mechanics which says; 'if it works – leave it alone'. This should be borne in mind when dealing with carburettors.

## 2 Removing the carburettor(s) from the machine

This job ranges from being remarkably simple to frustratingly involved, the complexity of the problem being directly proportional to that of the machine. Some form of workshop manual can be of great help here, and may save much unnecessary dismantling as there is often a 'knack' to tackling this task. Failing this, the job should not be beyond most motorcyclists with some experience of home maintenance.

The carburettor(s) are generally found to the rear of the cylinder head, although on small two-strokes with rotary valve induction systems, the instrument resides in its own chamber behind an engine side casing.

On all machines, it will be necessary to disconnect the fuel pipe(s) having first made sure that the tap(s) are turned off. In many cases, it is helpful to remove the fuel tank to gain unrestricted access to the carburettor(s). On simple slide carburettor installations, it will not be necessary to dismantle the

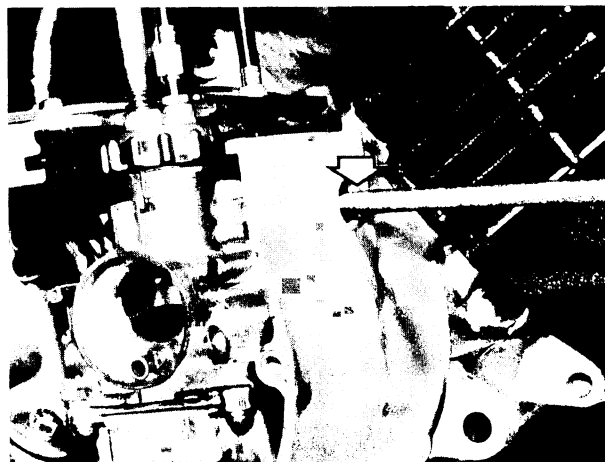
throttle valve assemblies from the throttle cable, it sufficing merely to release the mixing chamber top(s) and to withdraw the throttle valve(s) which can then be lodged clear of the carburettor bodies together with their cables.

On more complex installations, particularly those in which CD instruments are used, a common operating linkage is controlled by a single throttle cable or paired opening and closing cables which control the throttle via a pulley or quadrant arrangement. In these instances the cable(s) must be detached after the cable adjusters have been slackened off or removed as required. Very occasionally, it may prove advantageous to leave the cable(s) in place until the carburettor bank has been partially removed, if access is difficult.

On machines having a cable-operated cold-start system or strangler (choke) valve, release the control cable. It may prove necessary to release the cable at the control lever or knob, in some instances, to obtain sufficient slack to permit removal.

Release the screw clips or spring retainers which secure the air cleaner hoses to the carburettors. Where there is little manoeuvring room, it may prove helpful to release the screws securing the air cleaner case or plenum chamber so that it can be displaced during removal. On a few machines it is necessary to remove it entirely.

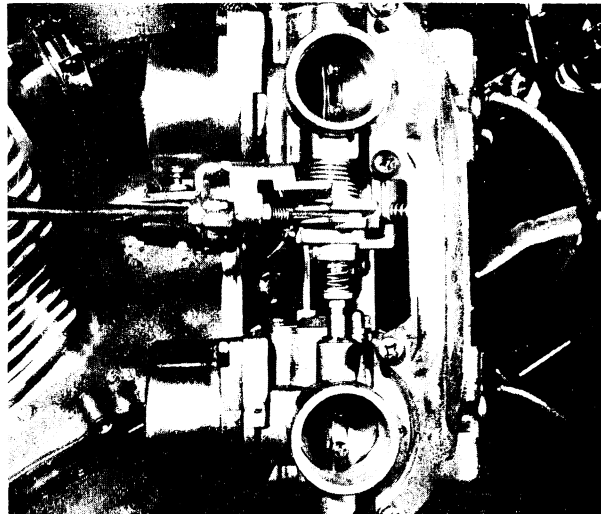
Having released all external connections the instrument(s) can be removed. On single-carburettor machines, it should only be necessary to release the retaining clip or nuts, allowing the carburettor to be disengaged and lifted away. Where two or more instruments are fitted, these are usually removed as an assembly after the retaining nuts have been unscrewed. On many three or four cylinder machines, the carburettors are fitted to a mounting plate. They should be removed with the plate and separated from it at a later stage. A certain amount of careful persuasion will be necessary to manoeuvre the assembly clear of the engine and frame.



9.1 On this Yamaha YB100, a small hole is provided to allow the carburettor mounting clamp to be released



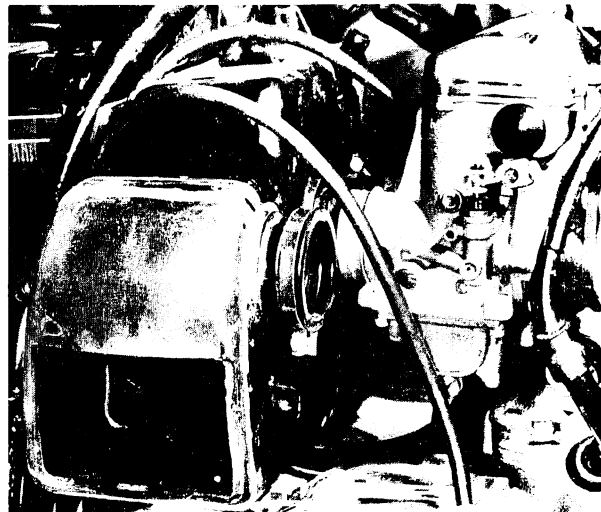
9.2 The carburettor is withdrawn from its housing, and the throttle valve assembly released. (Yamaha YB100)



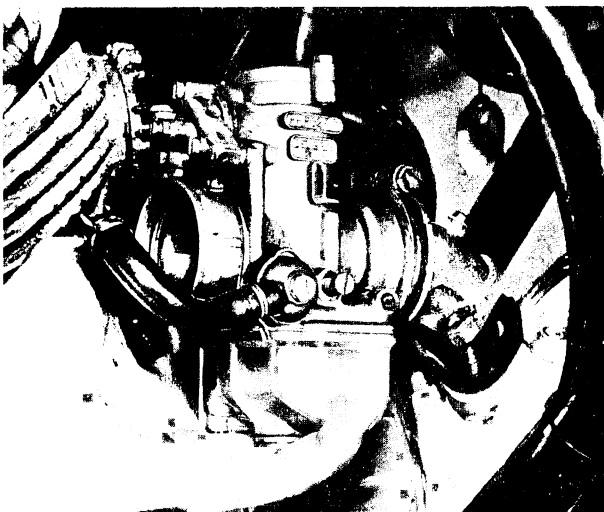
9.3 In the case of this Honda, the two instruments must be manoeuvred clear of the mounting stubs



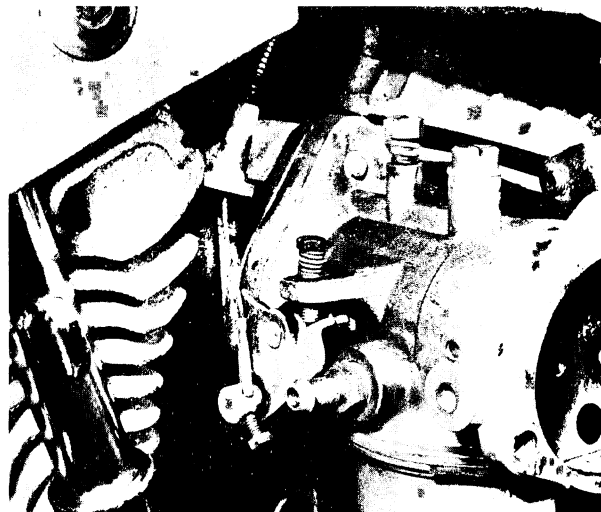
9.4 Once clear of the engine, the throttle cables can be released (Honda Super Dream)



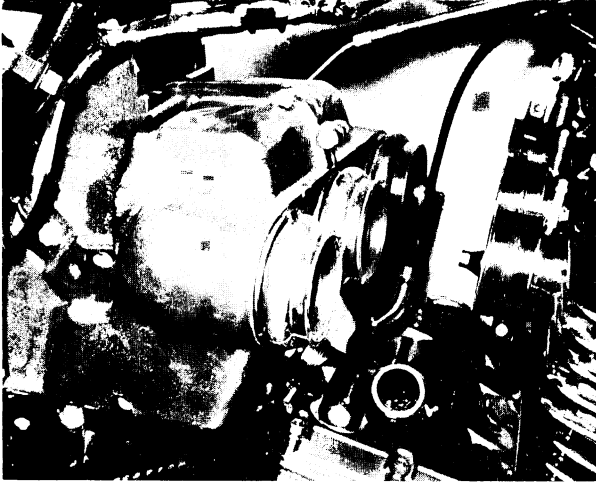
9.5 On multi-cylinder engines, the carburetors are invariably a tight fit. It may prove necessary to displace the air cleaner casing



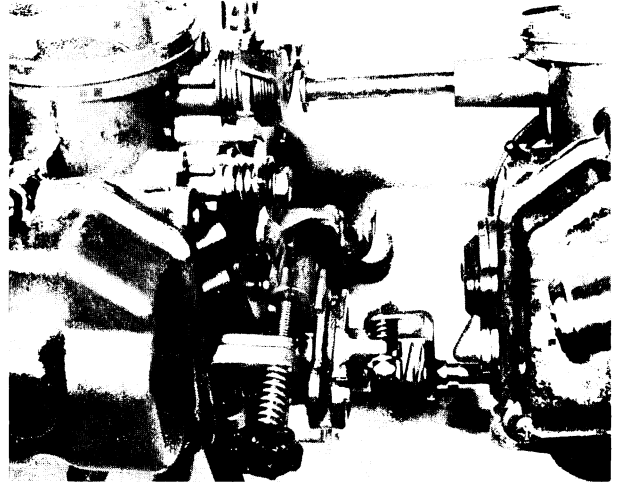
9.6 Access is no great problem on machines such as the Ducati V-twins



9.7 Harley Davidson V-twins offer good accessibility for carburetor removal



9.8 This view of the Yamaha XS750 shows the limited space between inlet and air cleaner stubs

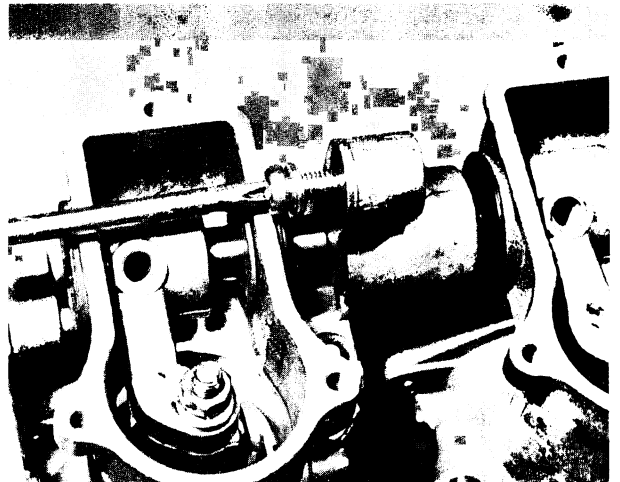


9.9 On machines with two or more cylinders, some form of linkage is normally fitted between the instruments

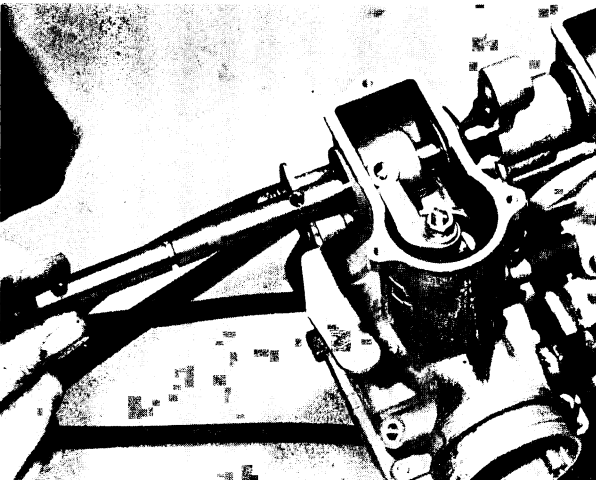
### 3 Dismantling slide-type carburettors

Begin by cleaning the external surfaces of the carburettor(s) and linkage using a degreasing solvent. It is important to remove all residual road dirt before dismantling commences, because this will lessen the risk of the internal drillings and jets becoming contaminated. The solvent can be applied with a small paint brush or an old toothbrush to ensure that the numerous awkward recesses are completely clean.

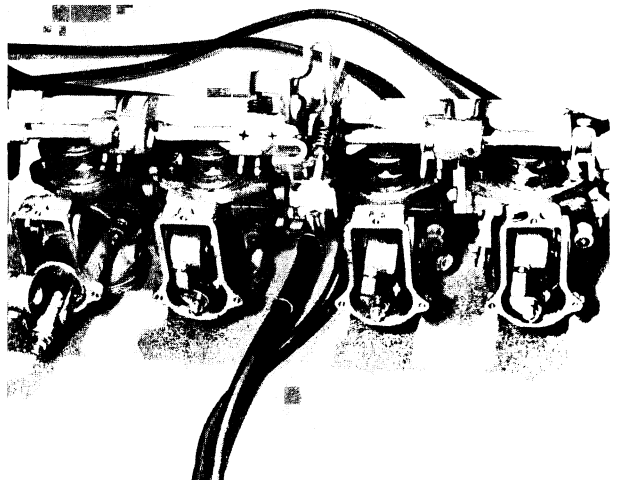
When dealing with a multi-carburettor arrangement, it will be necessary to release the individual instruments from their mounting bracket and operating linkage. Examination of the connecting linkage will give some indication of the method of removal, this being dependent on the type of carburettor employed. The lever or rocker arm type is popular on four-cylinder machines, having an external linkage which operates the throttle valves via the internal rocker arm housed at the top of the mixing chamber. In most cases, the carburettors can be removed either singly or in pairs without disturbing the connecting linkage.



9.10 Suzuki (GS750) Release the rocker arm bolts and shaft retainer on each instrument

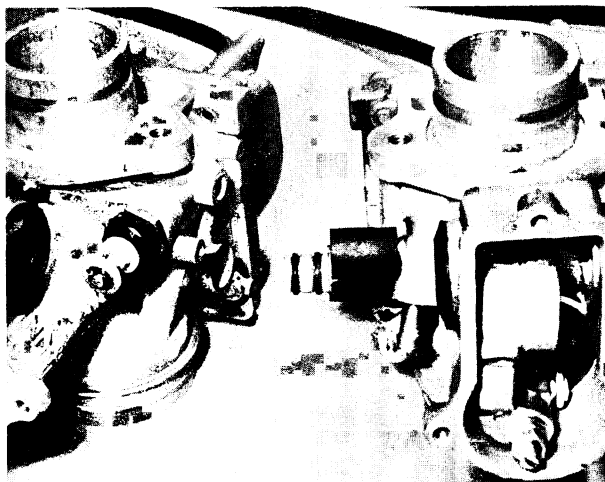


9.11 (Suzuki GS750) Throttle shaft will slide out from end of carburettor bank

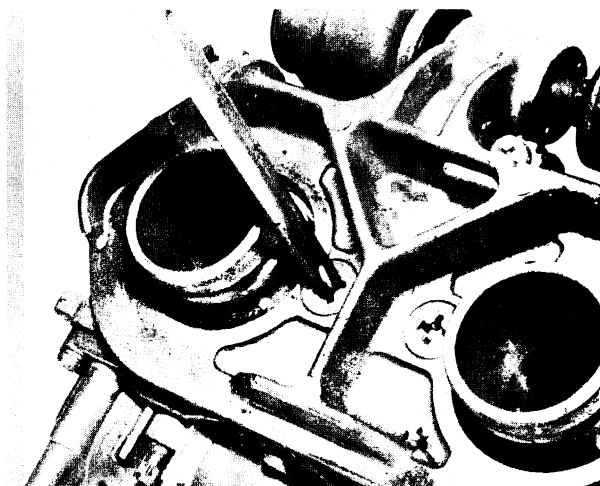


9.12 (Suzuki GS750) Cold start linkage and manifold plate are released as shown

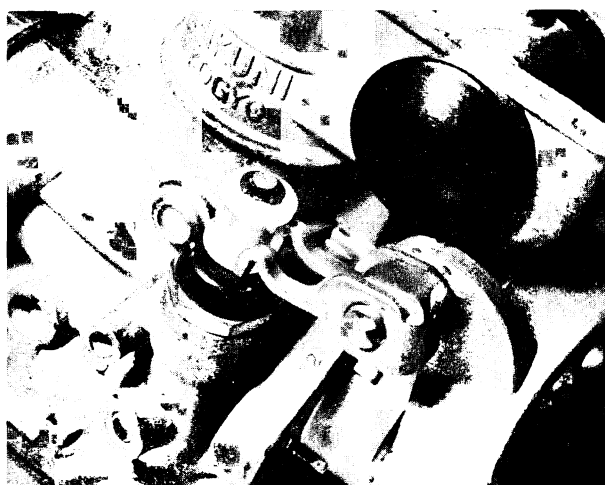




9.13 (Suzuki GS750) Carburetors are now held by fuel connections and may be pulled apart



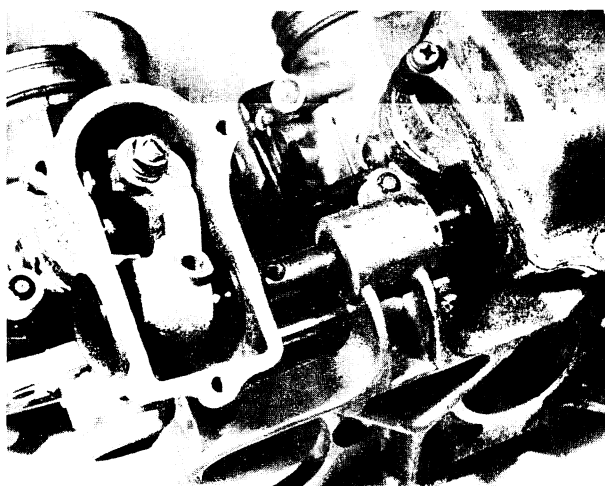
9.14 (Kawasaki 650) Release cast manifold plate by removing countersunk screws



9.15 (Kawasaki 650) Plate will swing clear, freeing the cold start shaft



9.16 (Kawasaki 650) Rocker arms are secured by stop bolts



9.17 (Kawasaki 650) Carburetors can now be pulled clear as shown

On some twin cylinder machines, the carburetors are completely independent of each other, there being provision for synchronisation by means of adjusters incorporated in the twin operating cables. These can be dealt with as two separate units, and can even be removed and overhauled singly if required. On the majority of multi-carburettor systems, however, the instruments must be treated as a complex assembly, and are thus retained by means of a steel or cast alloy mounting bracket. The individual instruments can be released from the bracket after the relevant connecting linkage has been released. Each instrument is normally retained by screws which are fitted from the engine side of the bracket.

Once the instruments have been removed and separated, it is important that they are kept in order. To this end each carburettor should be placed in a suitably marked box. If any peculiarities of the connecting linkage were apparent during dismantling, make a written note or sketch now, as an aid to reassembly. This is particularly important if an appropriate workshop manual is not available, because the invaluable exploded drawing giving details of the various connections will not be to hand when the time comes to refit the instruments. It should be stressed here that it is essential to dismantle, overhaul and rebuild each carburettor in turn, to preclude any possibility of the various components becoming interchanged between instruments.

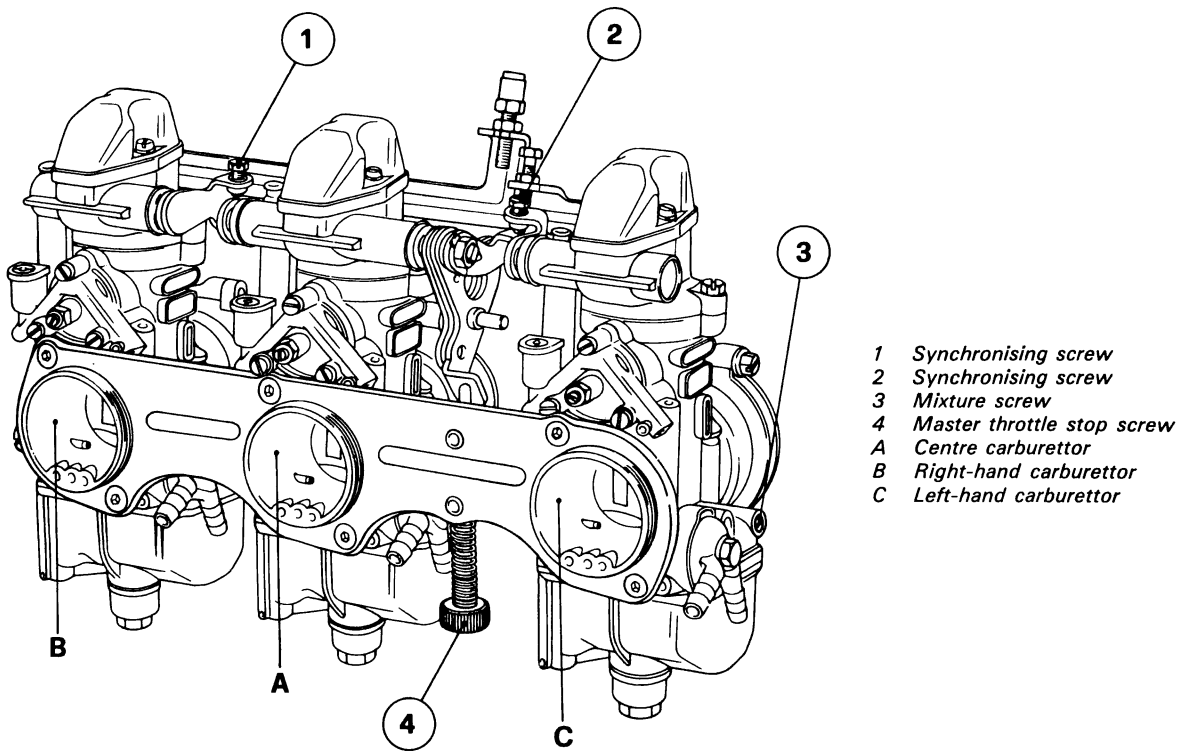


Fig. 9.1 Triple Dellorto arrangement, as fitted to Laverda motorcycles

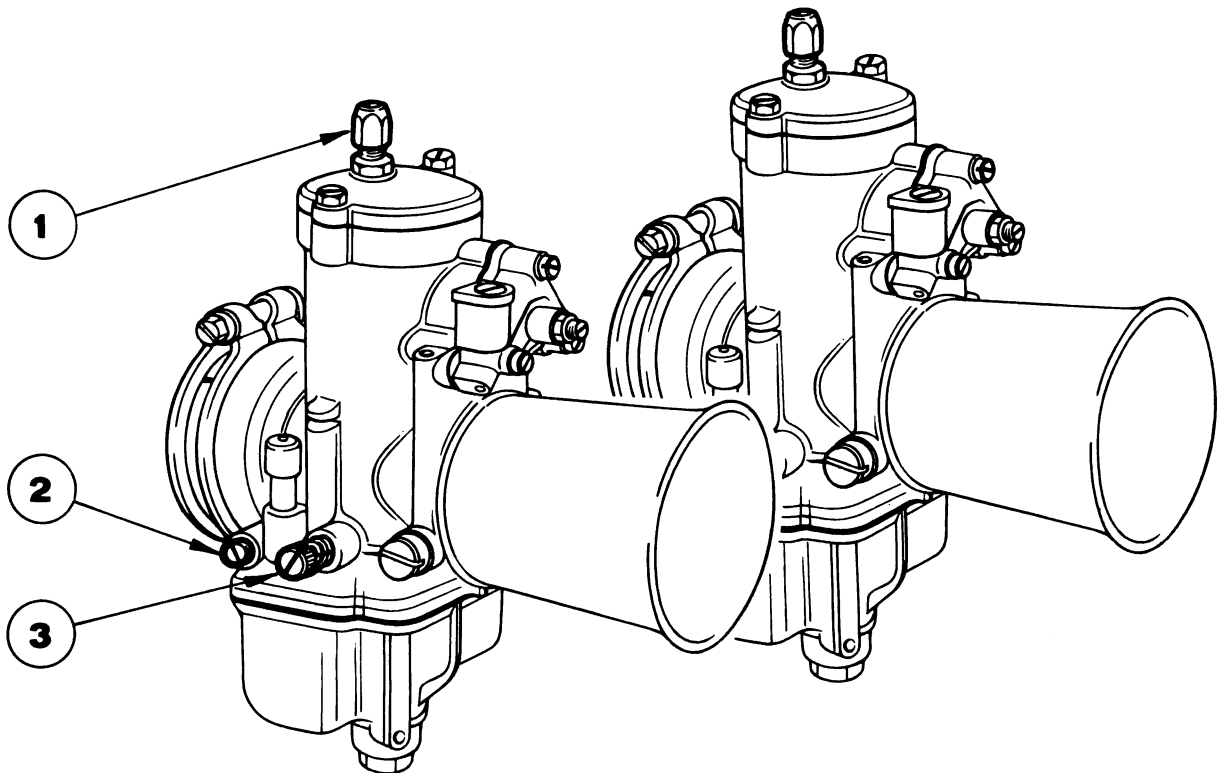


Fig. 9.2 Dellorto PHM type carburettors as used on Ducati and BMW models

On most single and many twin carburettor arrangements, the throttle cable(s) engage directly with the throttle valve, and on these machines, the mixing chamber top, throttle valve and jet needle will have been withdrawn during the removal sequence. To release the cable from the throttle valve it will be necessary to compress the return spring against the mixing chamber top to allow the cable to be pushed down and the nipple disengaged from its recess in the valve. On some carburettors, the design of the needle retaining clip is such that it will be helpful to displace the needle slightly to allow the cable to be freed.

A similar type of carburettor was employed on some of the earlier Honda fours, but on some models a slightly modified throttle valve operating mechanism was used. A rod was fitted through the carburettor top, and engaged with the throttle valve in place of the normal cable. The rod terminated in an adjuster

and locknut which was connected in turn to a forked rocker arm and connecting spindle. On these instruments, the mixing chamber top, throttle valve and needle can be removed in a similar manner to that described for the cable types, once the rocker arm mechanism has been detached.

The most popular slide carburettor in common use in multi-carburettor arrangements is the rocker arm or lever type. The top of the mixing chamber is enlarged to incorporate a rocker which is pivoted on a spindle. A ball-ended pin is fixed at the end of the rocker, forming the attachment point for an adjustable link. The link extends down into the carburettor, and is anchored by a similar pin to the throttle valve. In this way, the up and down movement of the throttle valve is converted to a rotary motion, this being suited to connection to the remaining instruments via spindles or links.

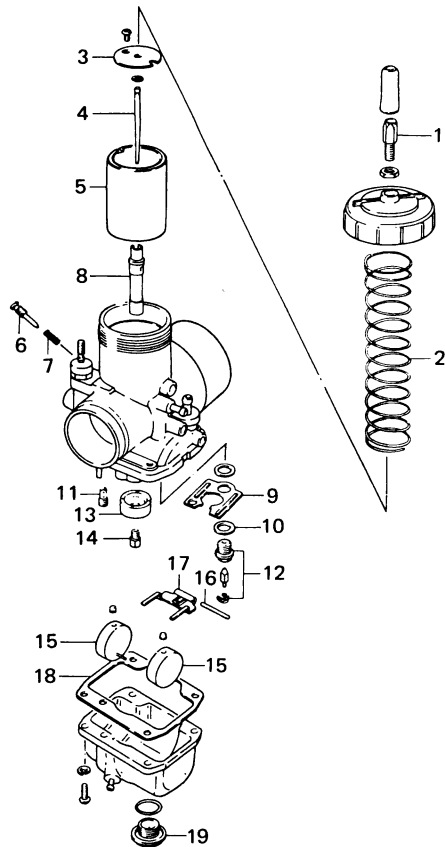


Fig. 9.3 Slide carburettor with baffled, independent float system – Suzuki RM 400

- |                                |                         |
|--------------------------------|-------------------------|
| 1 Cable adjuster               | 10 Valve seal gasket    |
| 2 Throttle valve return spring | 11 Pilot jet            |
| 3 Throttle spring seat         | 12 Needle valve assy    |
| 4 Jet needle                   | 13 Ring                 |
| 5 Throttle valve               | 14 Main jet             |
| 6 Pilot air screw              | 15 Float                |
| 7 Spring                       | 16 Float pin            |
| 8 Needle jet                   | 17 Float chamber arm    |
| 9 Float chamber plate          | 18 Float chamber gasket |
|                                | 19 Drain plug           |

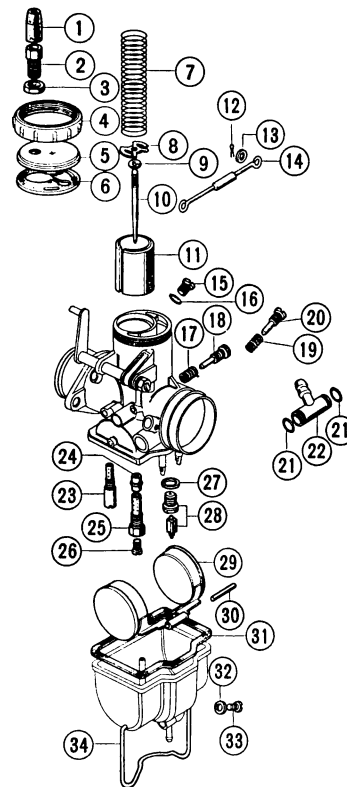


Fig. 9.4 Slide carburettor, as fitted to early Honda CB750 models

- |                       |                               |
|-----------------------|-------------------------------|
| 1 Rubber cap          | 19 Throttle stop screw spring |
| 2 Cable adjuster      | 20 Throttle stop screw        |
| 3 Locknut             | 21 7.9 x 1.9 O-ring           |
| 4 Cap                 | 22 T-type fuel tube joint     |
| 5 Top                 | 23 Slow jet                   |
| 6 Top washer          | 24 Needle jet                 |
| 7 Throttle spring     | 25 Needle jet holder          |
| 8 Needle set plate    | 26 Main jet                   |
| 9 Clip                | 27 Flat washer                |
| 10 Jet needle         | 28 Float valve set            |
| 11 Throttle valve     | 29 Float                      |
| 12 1.0 x 10 split pin | 30 Float arm pin              |
| 13 5 mm flat washer   | 31 Float chamber washer       |
| 14 Choke rod          | 32 6 mm flat washer           |
| 15 Plug screw         | 33 Drain plug                 |
| 16 Flat washer        | 34 Float chamber set clip     |
| 17 Air screw spring   |                               |
| 18 Air screw          |                               |

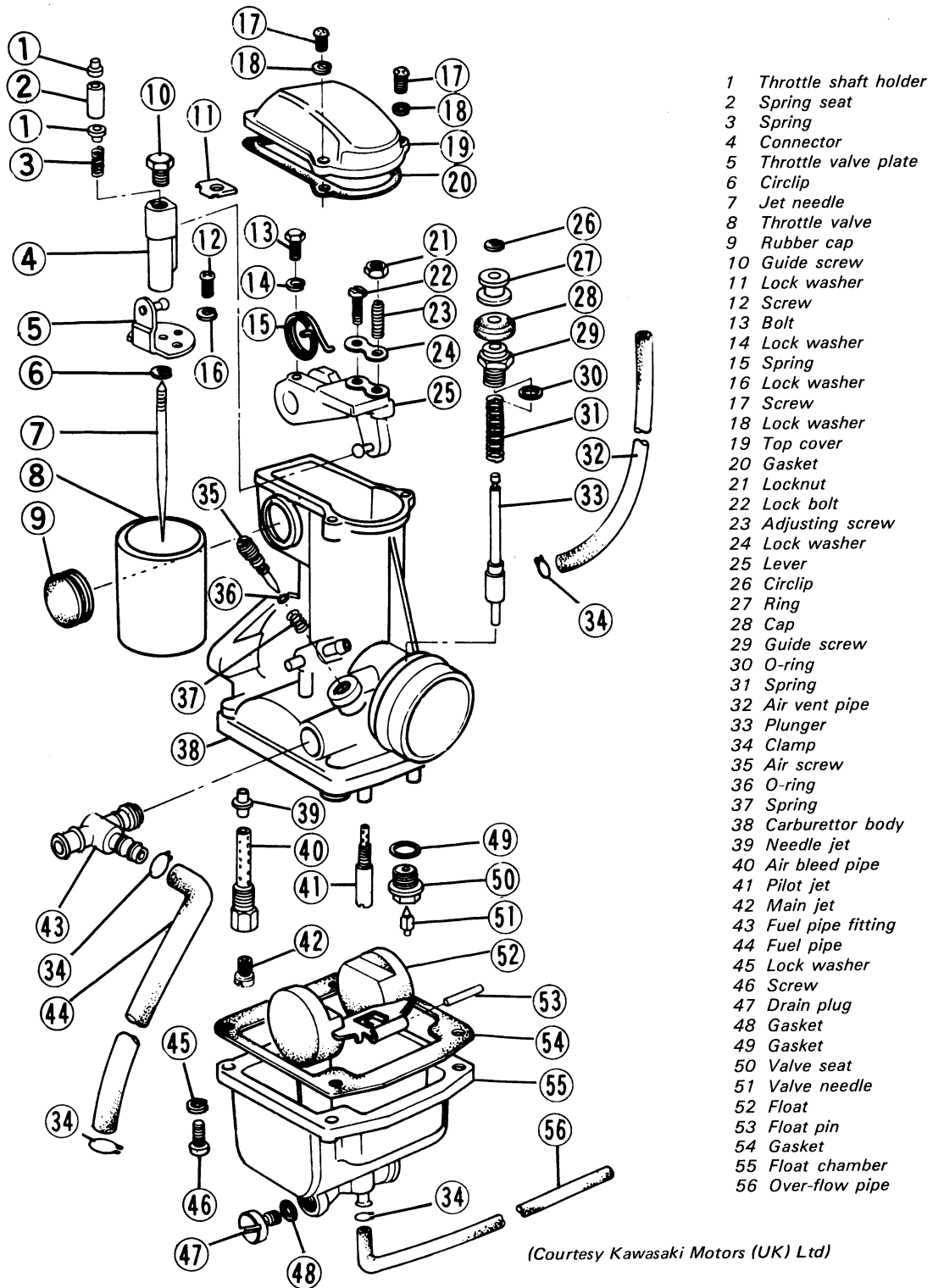


Fig. 9.5 Typical rocker arm type slide carburettor as fitted to Kawasaki Z900

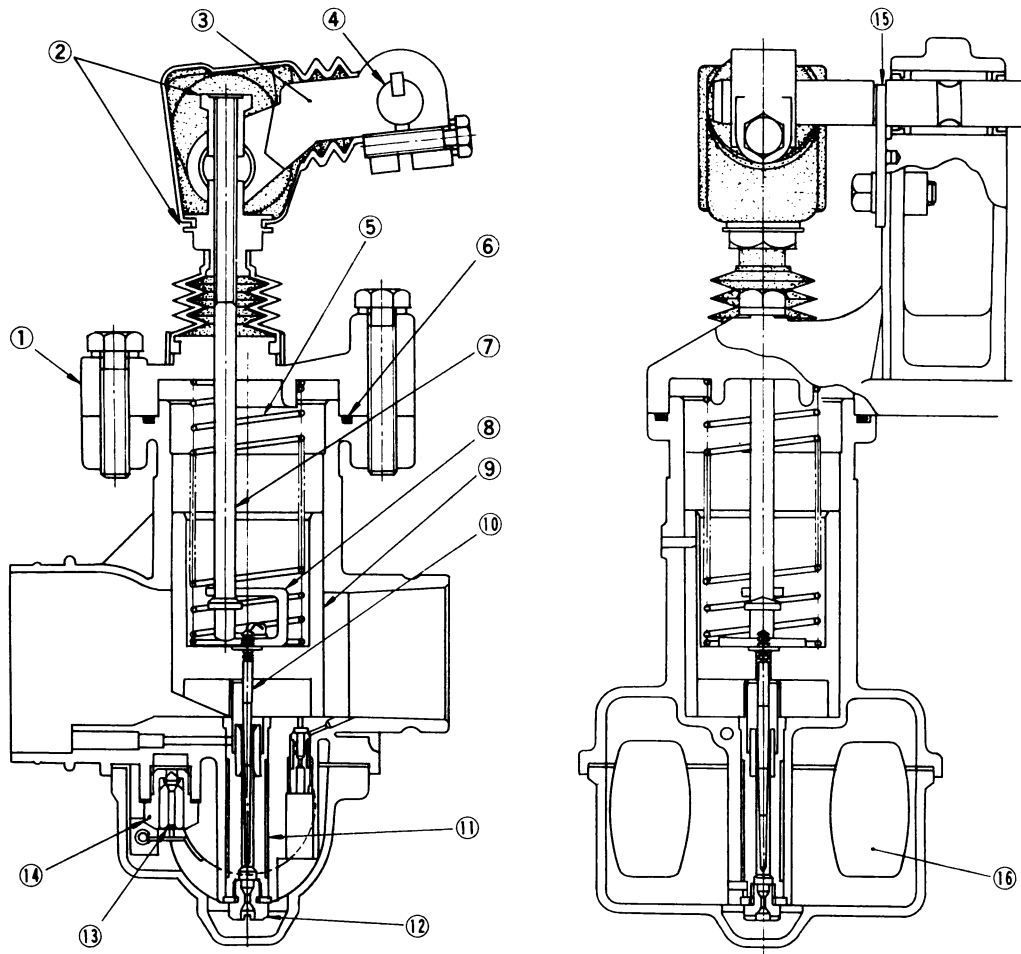


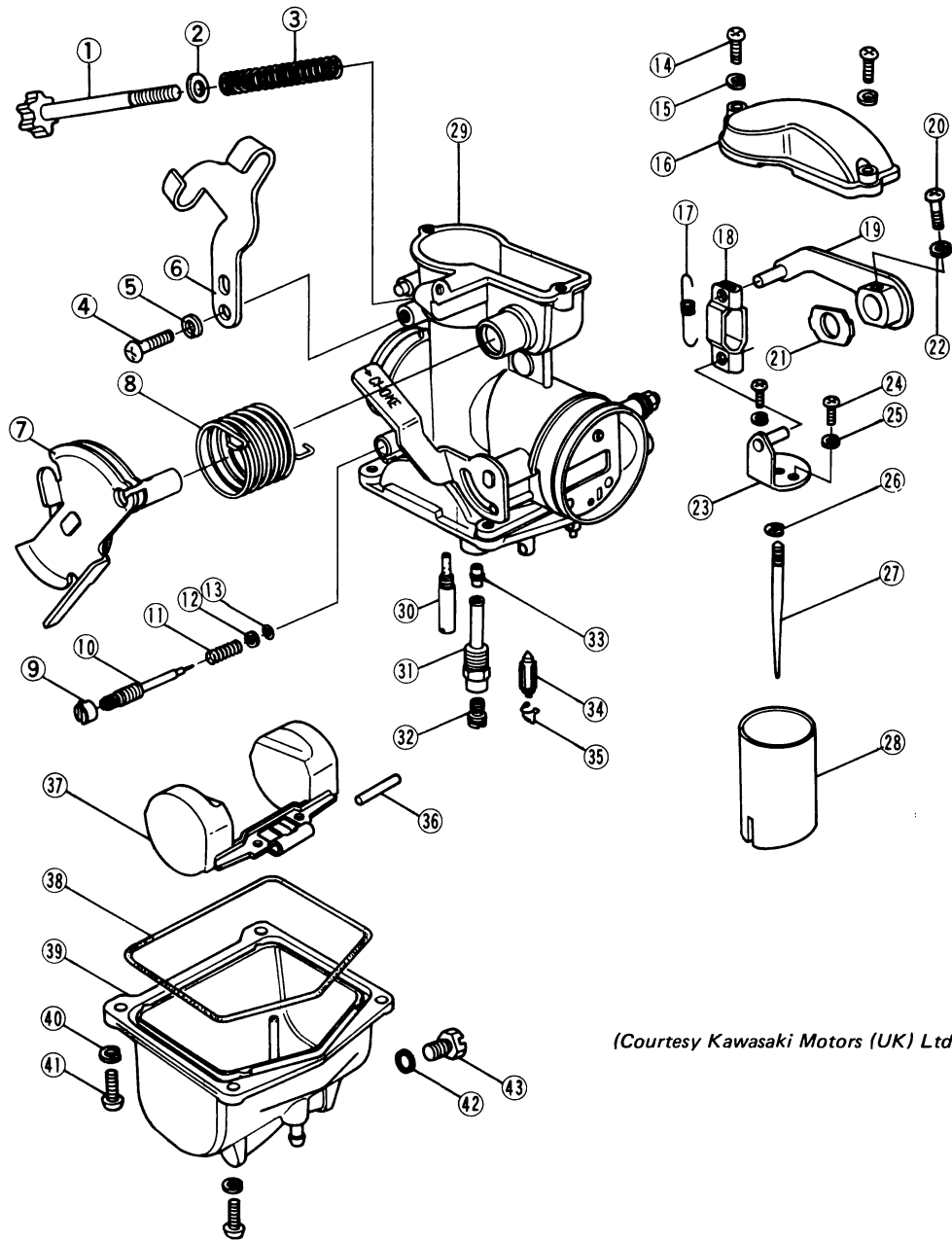
Fig. 9.6 Cross section view of rod-operated slide carburettor – Mikuni VM type as fitted to Suzuki GT380/GT550

- |   |                           |    |                      |    |                  |
|---|---------------------------|----|----------------------|----|------------------|
| 1 | Mixing chamber top        | 7  | Throttle valve rod   | 12 | Main jet         |
| 2 | Throttle valve adjust nut | 8  | Jet needle set plate | 13 | Needle valve     |
| 3 | Throttle valve arm        | 9  | Throttle valve       | 14 | Valve seat       |
| 4 | Throttle valve shaft      | 10 | Jet needle           | 15 | Shaft stop plate |
| 5 | Throttle valve spring     | 11 | Needle jet           | 16 | Float            |
| 6 | O-ring                    |    |                      |    |                  |

To remove the throttle valve assembly remove the screws which secure the mixing chamber cover, and detach this, taking care not to damage the gasket. Where a continuous shaft is employed, slacken the clamp bolt on the top of each of the rocker arms, remove the locating plate, where fitted, and withdraw the throttle shaft. On other machines such as the Kawasaki Z900, individual spindles are employed, these being inter-connected by a system of levers. In this case the individual shafts can be removed after the carburettors have been separated. Once the pivoted end of the rocker arm has been freed, the rocker arm, the adjustable link and the throttle valve assembly can be withdrawn. To remove the throttle valve from the operating mechanism, remove the screws which secure the bracket to the inside of the valve. The rocker arm and link can be left undisturbed unless wear necessitates further dismantling. It should be noted that on many installations, throttle valve synchronisation is adjusted by altering the effective length of the connecting link, so dismantling this assembly will necessitate setting up the throttle valves from scratch, and careful synchronisation after reassembly.

The 'bottom end' components of all slide-type carburettors are fairly similar and are quite easily dealt with. It must be stressed though, that absolute cleanliness is essential here. Remove the float bowl, which will be retained by two or more screws, or in a few cases, by a heavy wire clip. On Amal concentric and similar carburettors, the float, pivot pin and float valve needle will be freed as the float bowl is removed, and care should be taken to avoid loss or damage to these components. On most other carburettors, the float assembly is freed when its pivot pin has been displaced. The pin is a light sliding fit and can usually be shaken out of place. Failing that, a small piece of wire will prove useful in displacing it.

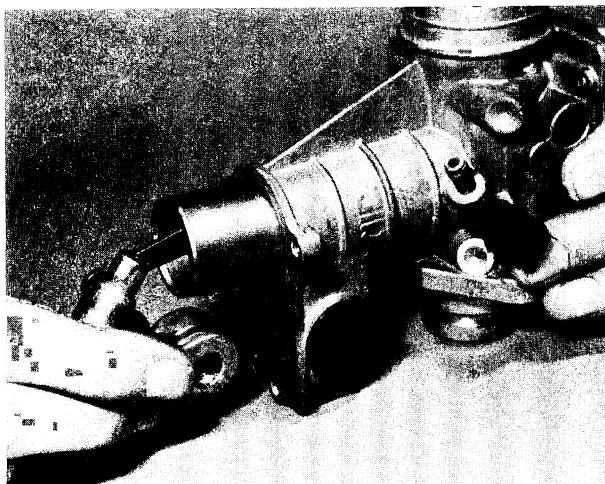
A few instruments, notably the larger Mikuni types, employ independent floats. It will be found that the two floats will remain attached to their support pins in the float bowl. These can be removed after the small retaining caps have been pulled off. The floats operate a conventional float valve via a forked operating arm. This can be removed in the same way as described for conventional paired floats.



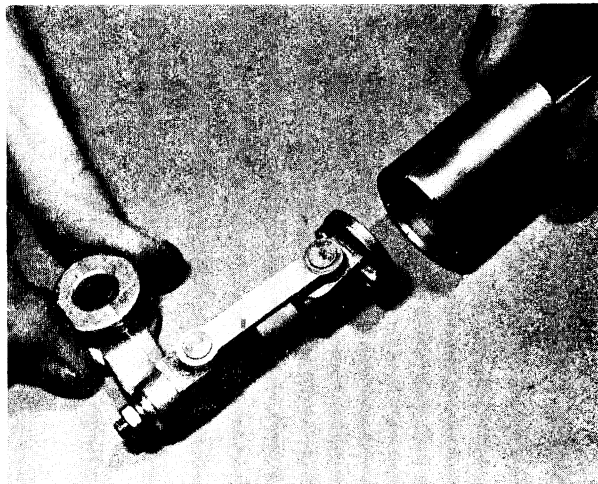
(Courtesy Kawasaki Motors (UK) Ltd)

Fig. 9.7 Rocker arm type slide carburettor as fitted to Kawasaki KL 250

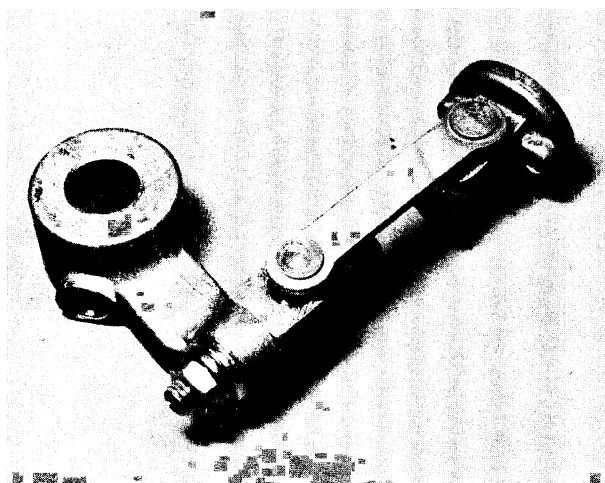
- |                          |                   |                           |                       |
|--------------------------|-------------------|---------------------------|-----------------------|
| 1 Idle adjusting screw   | 12 Washer         | 23 Throttle valve bracket | 34 Float valve needle |
| 2 Washer                 | 13 O-ring         | 24 Screw                  | 35 Hanger             |
| 3 Spring                 | 14 Screw          | 25 Lock washer            | 36 Float pin          |
| 4 Screw                  | 15 Lock washer    | 26 Clip                   | 37 Float              |
| 5 Lock washer            | 16 Top cover      | 27 Jet needle             | 38 O-ring             |
| 6 Throttle cable bracket | 17 Spring         | 28 Throttle valve         | 39 Float bowl         |
| 7 Pulley                 | 18 Link           | 29 Carburettor body       | 40 Lock washer        |
| 8 Spring                 | 19 Throttle arm   | 30 Pilot jet              | 41 Screw              |
| 9 Idle limiter           | 20 Screw          | 31 Bleed pipe             | 42 O-ring             |
| 10 Pilot screw           | 21 Plastic washer | 32 Main jet               | 43 Drain plug         |
| 11 Spring                | 22 Lock washer    | 33 Needle jet             |                       |



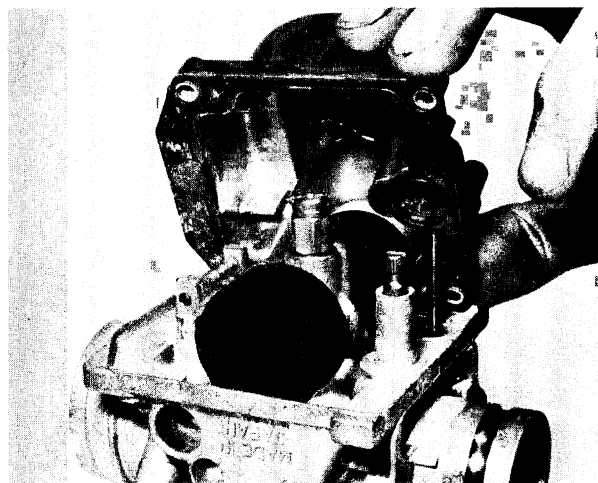
9.18 On rocker-arm type carburettors, the arm and linkage are withdrawn together with the throttle valve assembly



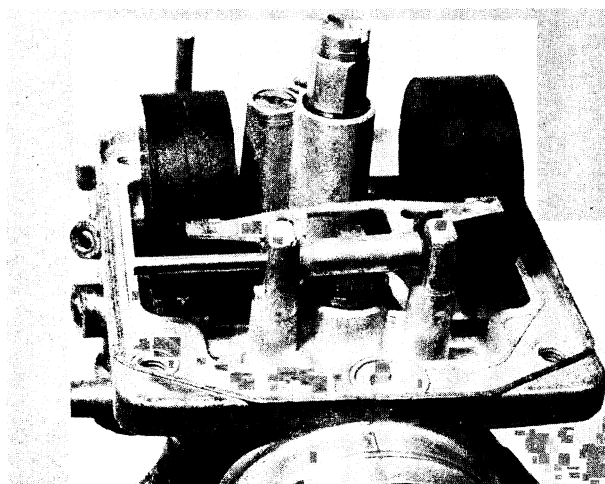
9.19 The rocker arm and link is secured to the throttle valve by screws



9.20 The rocker arm and connecting link



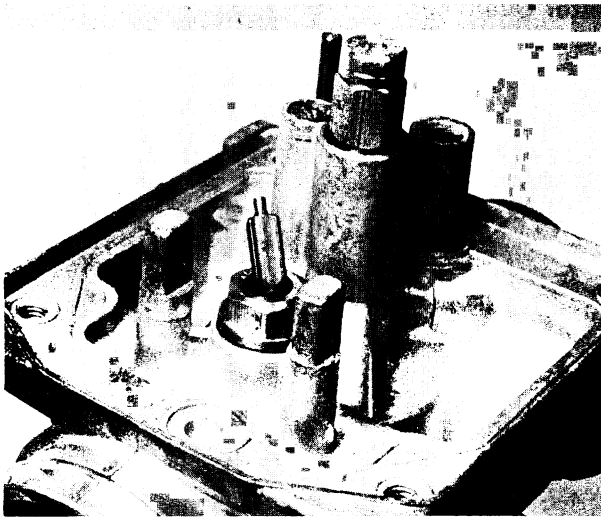
9.21 The float bowl is secured by screws, or in some cases, by a large wire clip



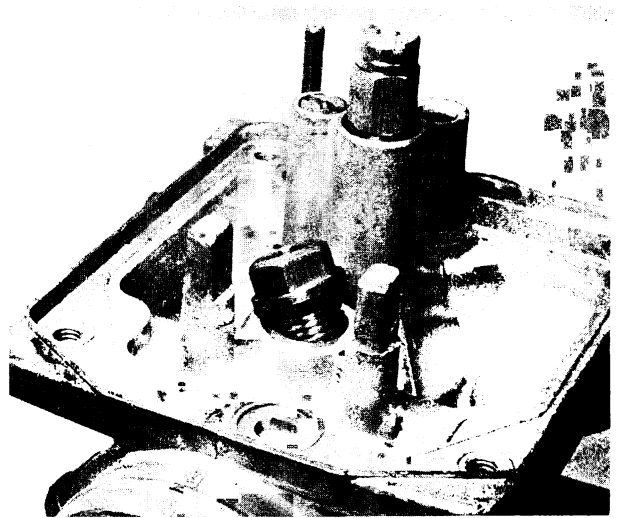
9.22 Displace the pivot pin to free the float assembly

The float valve consists of a body, which is normally made of brass and is detachable, and a tapered needle. The needle is usually freed when the float assembly is removed, but on a few models it is necessary to remove a clip to release it from either the valve body or the float arm. Where the valve body is removable, it is held by a retainer plate and screw, or more commonly, is screwed into the carburettor body. On some carburettors, the valve body is integral with the carburettor body or the float bowl, and thus, even if badly worn, cannot be renewed independently.

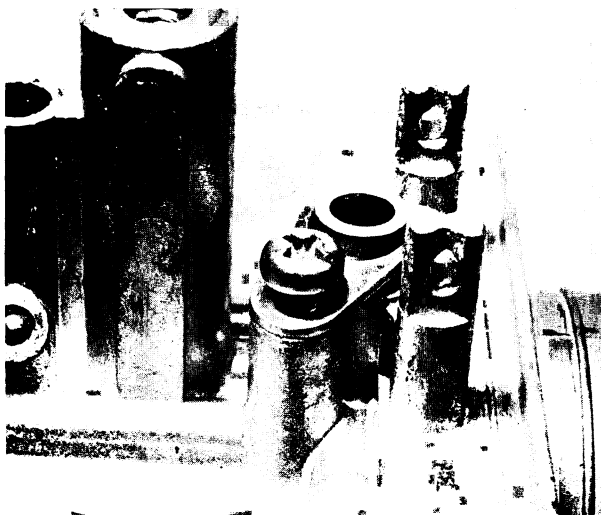
The various jets screw into the underside of the main carburettor body, and occasionally, into the float bowl casting. Care should be taken when removing them as they are made of brass which is easily damaged if the wrong size of screwdriver or spanner is used. It is normal practice to screw the main jet into the underside of the needle jet assembly, these two components being on the central axis of the carburettor. On many machines a drain plug is fitted at the centre of the float bowl to permit main jet changes to be made without having to remove or dismantle the entire carburettor. The main jet may be removed independently of, or together with, the needle jet assembly. The latter can be a one-piece affair, whilst on other types of carburettor the small needle jet screws into the top of a tubular jet holder. The needle jet and/or the jet holder may have a number of air bleed holes along its length.



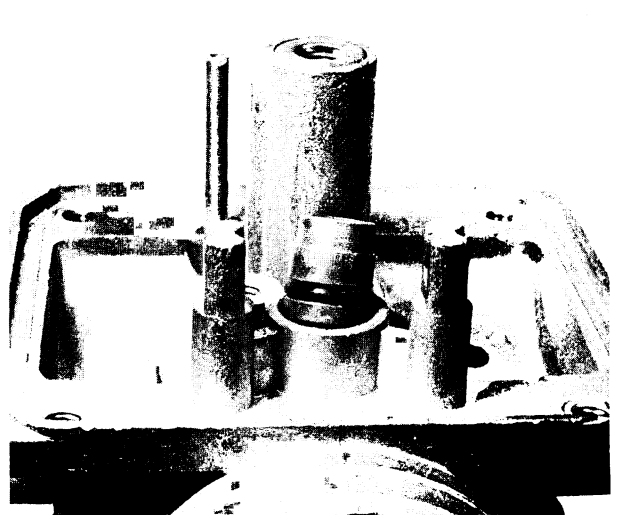
9.23 The float needle can now be removed



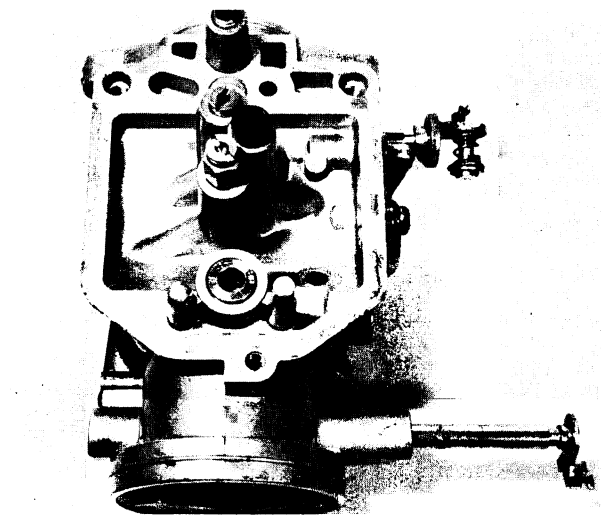
9.24 Float valve body is screwed into the carburetor body on most models



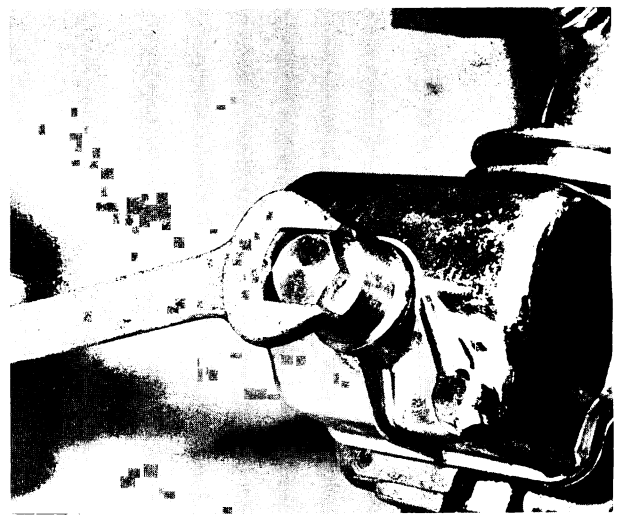
9.25 Some instruments use a retainer plate to hold the valve body



9.26 An O-ring seal is fitted to prevent leaks

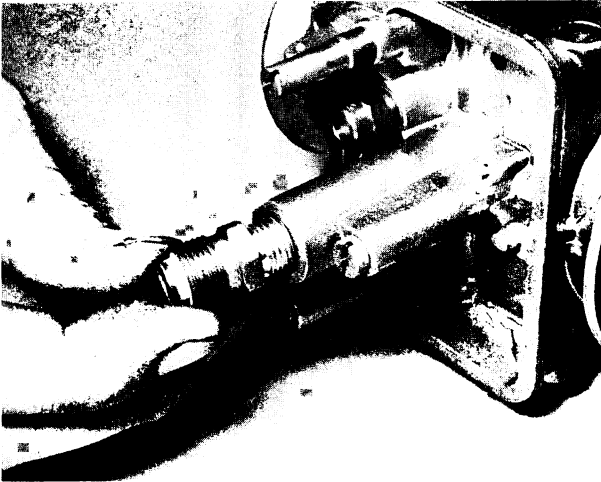


9.27 In a few cases, the valve body is integral with the carburetor, and cannot be removed



9.28 On this Dellorto instrument, the large drain plug secures the float bowl and provides quick access to the main jet

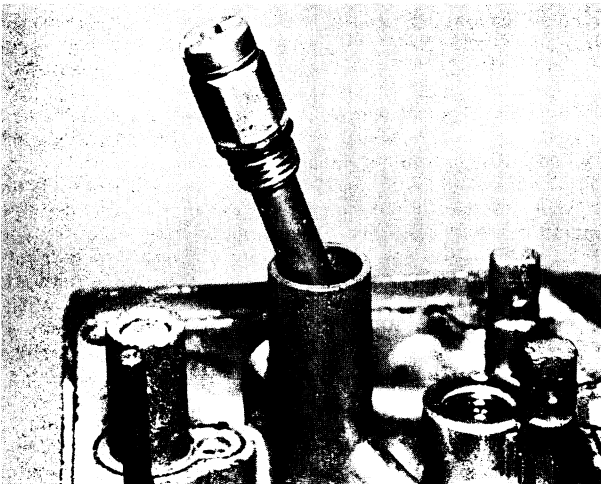




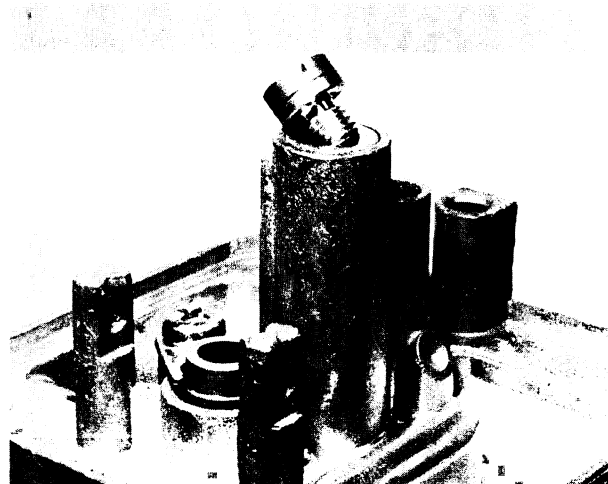
9.29 The main jet can be removed with the jet holder, if desired



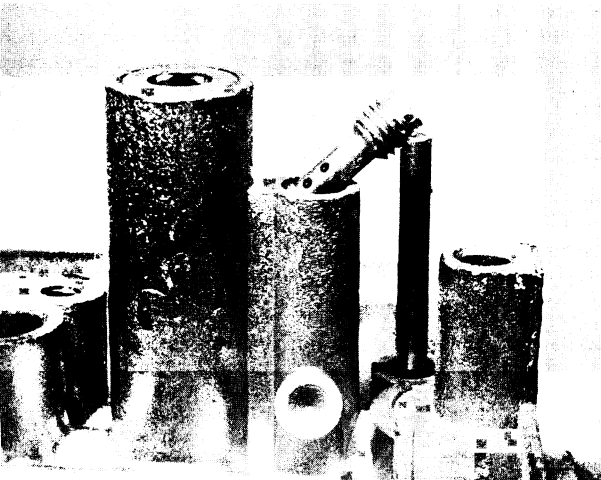
9.30 The needle jet is fitted concentrically with the main jet



9.31 The main jet and needle jet can often be removed together, as shown here



9.32 In this example, the main jet retains the needle jet, which can be displaced upwards



9.33 The pilot jet is normally located adjacent to the main jet

The pilot jet may be found in a number of locations, depending on the type and model of carburettor. The most common location is adjacent to the main jet/needle jet assembly. Some manufacturers have chosen alternative locations, such as the float bowl. On some Amal instruments no detachable pilot jet is fitted, and on these carburettors a specially sized pilot jet bush is inserted into the pilot circuit during manufacture. It should be noted that a thread will be evident where the conventional pilot jet is normally fitted, but this should be ignored on these models.

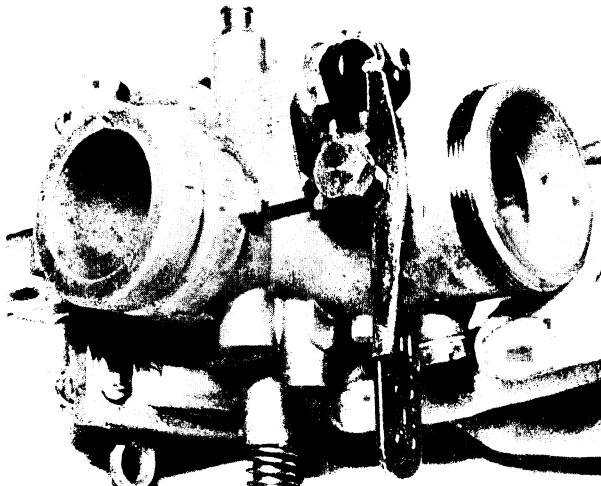
Other jets which may be encountered on rare occasions include a primary air jet. This is in fact more of a restrictor than a jet in the true sense, serving to effect a basic control on the rate of air flow into the main fuel system. The primary air jet will be found on the atmospheric side of the primary air passage. In the case of the Amal Concentric Mk II, the jet is retained by the air intake adaptor.

Very occasionally, it is necessary for the manufacturer to specify an additional jet or circuit to cater for particular demands of a particular application. This is usually in the form of an additional main jet circuit located on the engine side of the needle valve. Its purpose is to ease the transition *between* idle circuit and main jet/needle jet operation, and as such forms a secondary main or intermediate system. This presents no undue problems with overhaul procedure, representing nothing more

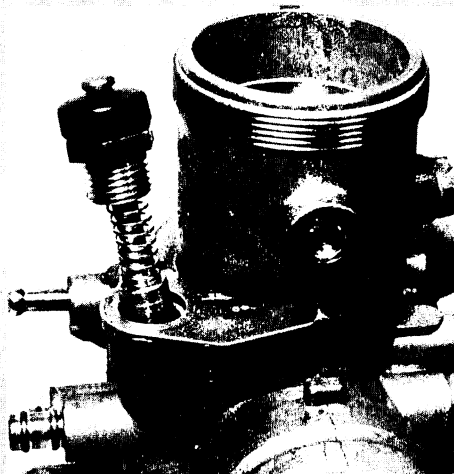
than an additional jet and passage to check. It is interesting to note that this type of carburettor is technically a hybrid between the slide and fixed jet types.

The cold-start system can take a number of forms, the simplest of which is a guillotine slide or a butterfly valve which operates on the atmospheric side of the throttle valve. It works by obstructing the air flow through the main choke, or venturi, and so depriving the engine of air. The resulting added depression causes the mixture to become grossly rich, and thus facilitates cold starting. The system is very simple in operation, and rarely warrants overhauling. The various parts may be removed for examination if required.

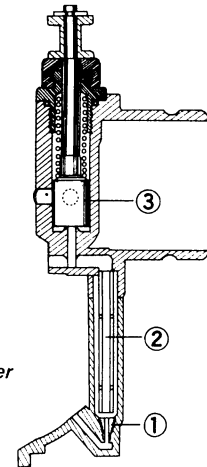
Increasingly popular is the mixture-richening system in which an entirely separate fuel/air circuit is employed solely for starting purposes. These circuits are turned on or off by means of a plunger mechanism mounted to one side of the mixing chamber. The plunger assembly can be unscrewed for examination, as can the operating lever, where fitted. On a few two-stroke machines, a small secondary venturi is arranged inside the carburettor enabling the discharge orifice of the cold-start system to be placed in the centre of the airstream. This system is not widely used, as a result of the disturbing effect it has on normal operation, and more commonly, the cold start mixture discharges through a small orifice in the main venturi wall.



9.34 The cold start plunger is often operated by a pivoting lever



9.35 The plunger body is held by a gland nut



- 1 Starter jet
- 2 Starter pipe
- 3 Starter plunger

Fig. 9.8 Typical plunger type cold-start mechanism

(Courtesy Kawasaki Motors (UK) Ltd)

#### 4 Dismantling CD carburettors

As mentioned previously, there are two basic types of CD instrument, and these can be categorised as the diaphragm (Stromberg) type and the piston (SU) type. This type of carburettor is rapidly finding favour with motorcycle manufacturers, who are under increasing pressure to make their machines run more cleanly. As with slide carburettors, they are used in single and multi-cylinder applications.

The installations using CD instruments are broadly similar to slide carburettor arrangements, and in consequence the operating linkages are much the same. Because butterfly-type throttle valves are employed, the return spring arrangements are usually less powerful than those used on slide instruments, and the linkage is often a comparatively lightweight affair. Usually, the throttle butterfly pivots are extended to form an adjustable connection between each instrument, a light coil spring being fitted concentrically to the spindle and serving to close the throttle.

The instruments are normally connected by a mounting bracket or brackets, the throttle linkages, the cold start linkage and by short, push-fit fuel pipes or adaptors. The procedure for removal is similar to that described for slide instruments, and Section 2 should be consulted as a general guide to the likely procedure for this operation. Once removed, the assembly should be dismantled ready for the overhauling of each instrument in turn.

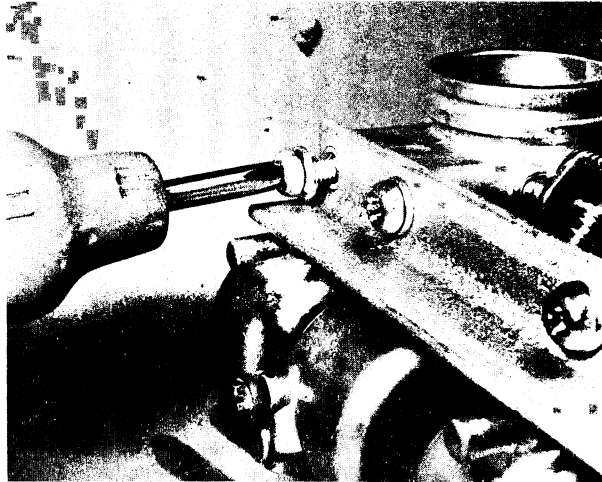
By far the most popular type of CD instrument in use on motorcycles is the diaphragm type, based on Stromberg designs. It is readily identified by its flat, round diaphragm housing at the top of the carburettor, and it is this flatness which gives it an advantage over the taller cylindrical piston housing of the SU type.

The diaphragm cover is secured by four screws, these often doubling as a means of retaining the mounting brackets. With the cover and piston spring removed, the synthetic rubber diaphragm is exposed, and should be lifted away very carefully to avoid damage. With the diaphragm will come the small piston — this corresponds to the throttle valve in slide carburettors — and the jet needle. The needle can usually be displaced up through the valve or piston together with its retaining clip. Occasionally, a small circlip must be removed first to permit this.

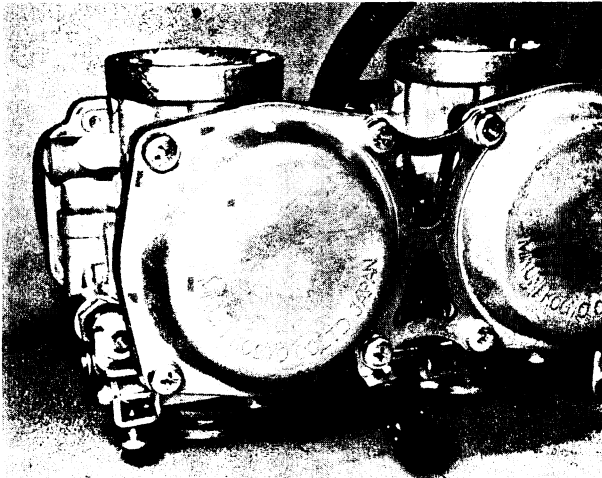
In the case of the piston or SU type, release the screws which secure the suction chamber assembly, and lift this away, together with the piston return spring, where fitted. Lift out the piston/valve unit and the attached jet needle. The latter is sometimes secured by a spring clip, but more commonly by a grub screw through the side of the piston. In the latter case a small needle holder is fitted at the top of the needle.

All CD instruments make use of a simple butterfly throttle valve which should not normally require attention. It has no direct effect on mixture strength, and thus does not require changing for tuning purposes, and being lightly loaded is not prone to extensive wear in use. If wear is present, it will be between the spindle and its bore in the carburettor body. On ageing instruments this fault can cause running problems due to air leakage. The only remedies are renewal of the carburettor, or possibly the boring out and bushing of the pivot bores. This is a specialised task calling for precise machining, and should be entrusted to someone with experience of this type of work. Although it can avoid the expense of renewal it must be remembered that the rest of the carburettor will be correspondingly aged and worn, so work out the overall cost of such a repair job before going ahead.

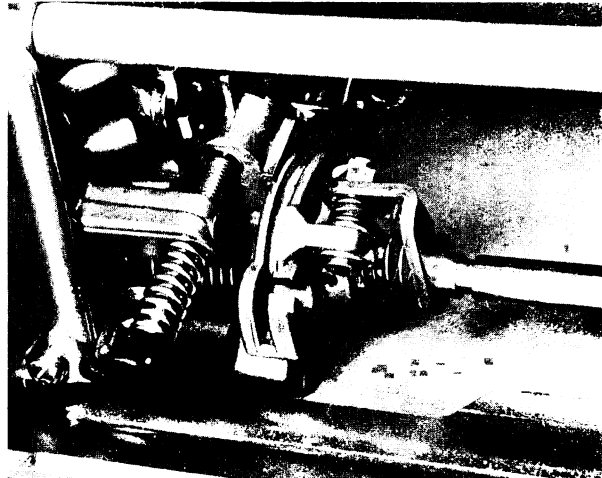
The float bowl components, including the various jets, are almost identical to those used in slide instruments, and the dismantling procedure described in Section 3 of this Chapter can be applied. The same is true of the cold-starting arrangement, this being of the mixture-richening circuit type in almost every case. Very occasionally, a second butterfly valve arrangement is used. This is fitted to the atmospheric side of the piston, and usually has a small spring-loaded flap valve to act as a pressure operated bypass to prevent stalling. Being simple and strong in construction there is nothing that can really go wrong with it, and it can safely be ignored for overhaul purposes.



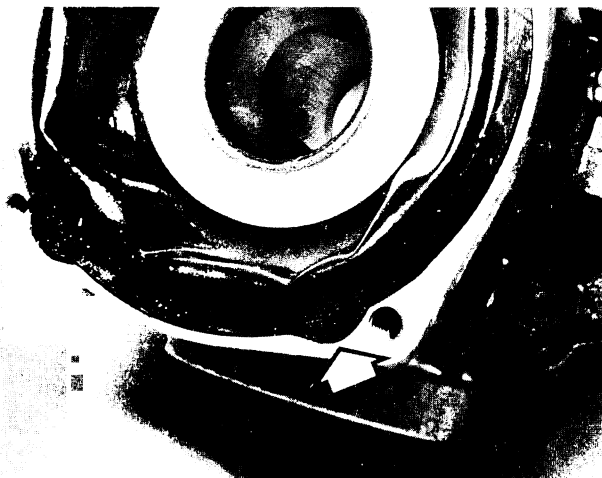
9.36 CD instruments are connected by brackets similar to those described for slide instruments



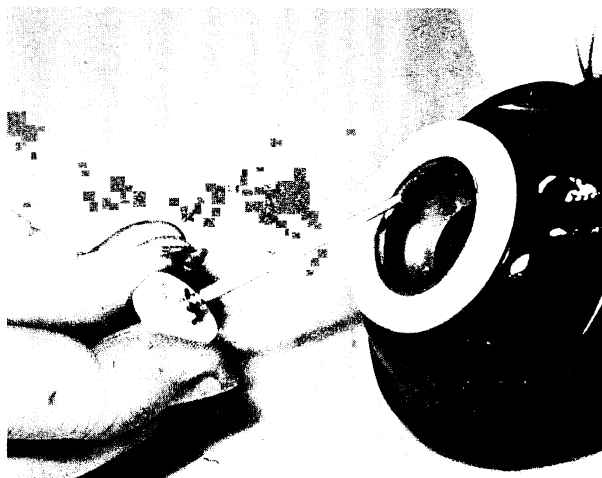
9.37 Additional top brackets are often fitted between the tops of the instruments



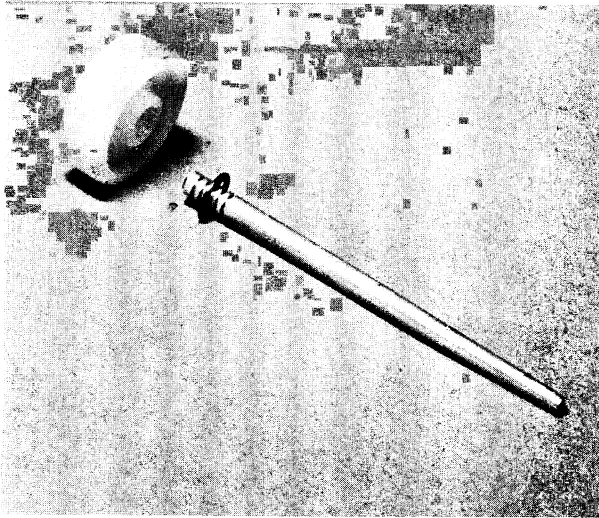
9.38 On this Honda twin, the carburettors are connected by a bracket, a fuel pipe and the throttle linkage



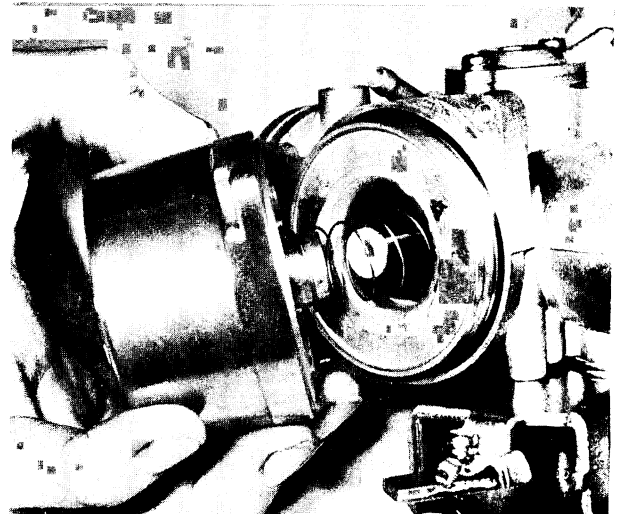
9.39 Diaphragm on Stromberg CD types is exposed after releasing the top cover. Note locating tabs



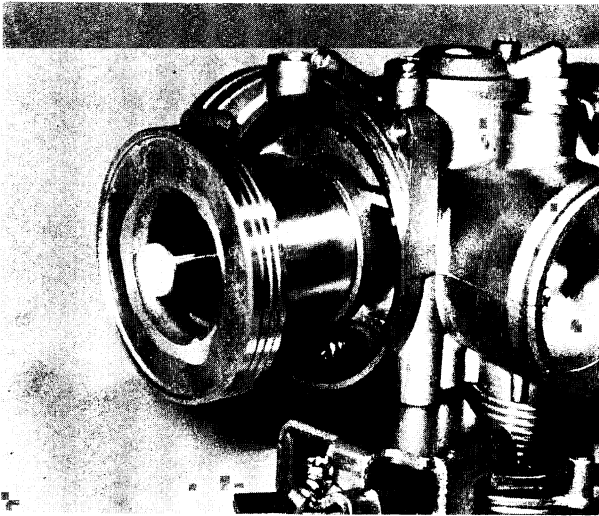
9.40 Jet needle is held by plastic retainer



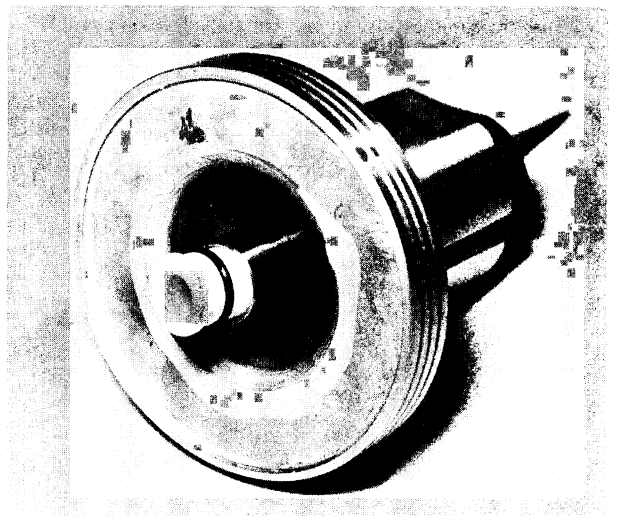
9.41 Needle and adjustment clip, together with the needle retainer



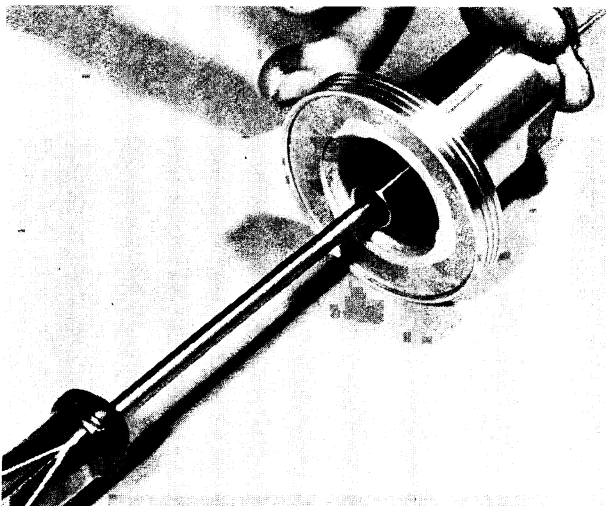
9.42 With SU types, remove the suction chamber and spring



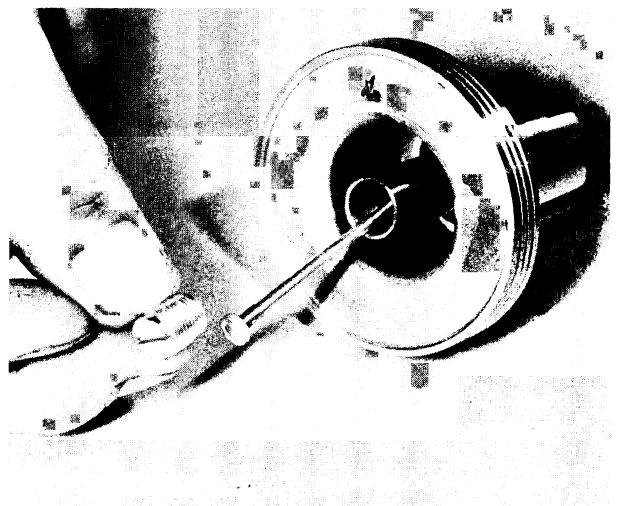
9.43 Piston/valve assembly can now be withdrawn from the carburettor body



9.44 Plug is fitted in top of piston



9.45 Slacken the grub screw to release the jet needle – screw may be as shown, or at the side



9.46 Jet needle and retaining grub screw

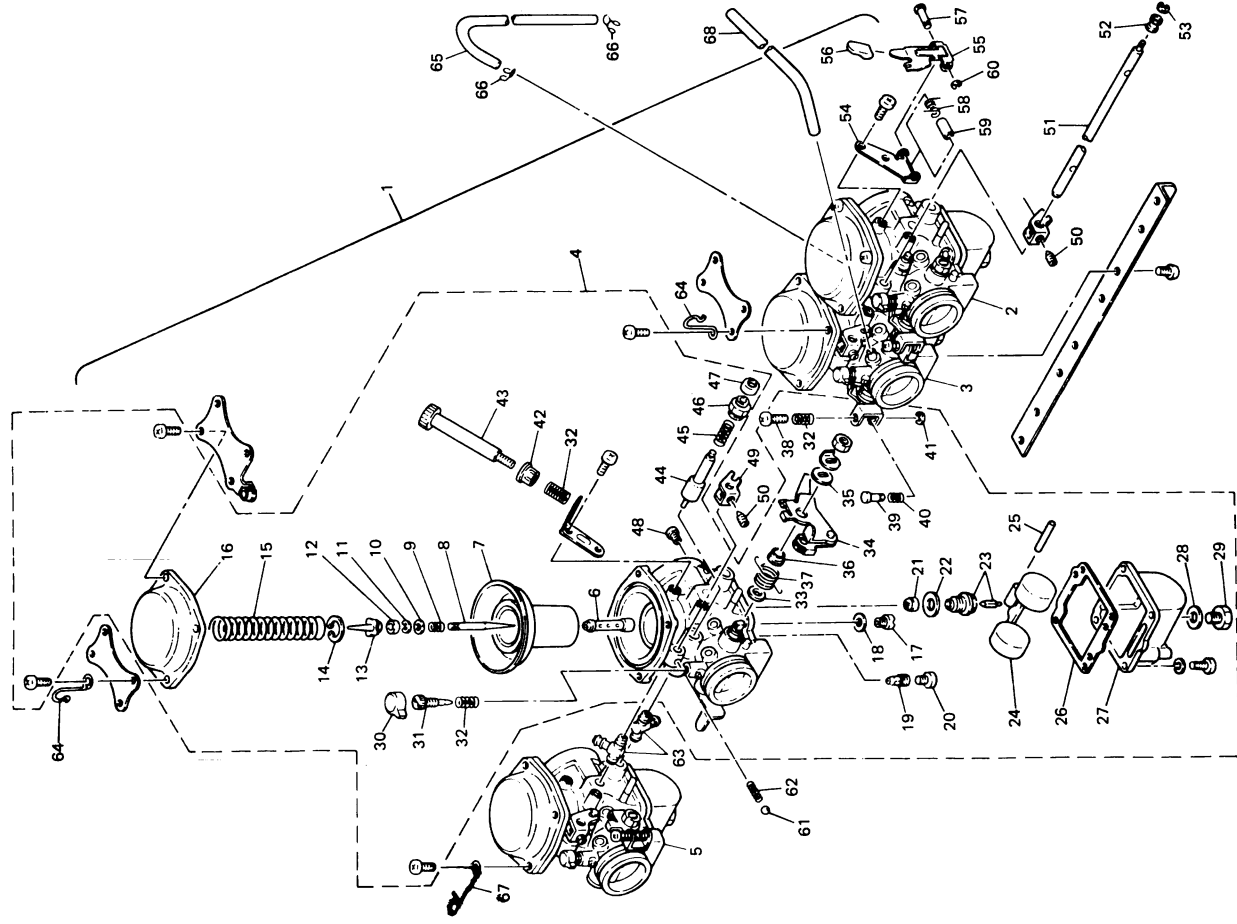


Fig. 9.9 Bank of four Mikuni BS34-11 2H7-00 CD carburettors as fitted to Yamaha XS 1100

- |    |                             |    |                         |    |                  |
|----|-----------------------------|----|-------------------------|----|------------------|
| 1  | Carburettor assembly        | 35 | Collar                  | 52 | Bush             |
| 2  | Carburettor - No 1 cylinder | 36 | Sleeve                  | 53 | E-clip           |
| 3  | Carburettor - No 2 cylinder | 37 | Throttle return spring  | 54 | Bracket          |
| 4  | Carburettor - No 3 cylinder | 38 | Throttle stop screw     | 55 | Cold start lever |
| 5  | Carburettor - No 4 cylinder | 39 | Push rod                | 56 | Cap              |
| 6  | Main nozzle/needle jet      | 40 | Spring                  | 57 | Clevis pin       |
| 7  | Diaphragm and valve         | 41 | E-clip                  | 58 | Spring           |
| 8  | Jet needle                  | 42 | Bush                    | 59 | Sleeve           |
| 9  | Needle spring               | 43 | Idle speed control knob | 60 | E-clip           |
| 10 | Washer                      | 44 | Cold-start plunger      | 61 | Detent ball      |
| 11 | Needle clip                 | 45 | Spring                  | 62 | Spring           |
| 12 | Spacing ring                | 46 | Plunger gland nut       | 63 | T-piece          |
| 13 | Fitting plate               | 47 | Dust seal               | 64 | Guide clip       |
| 14 | Circlip                     | 48 | Pilot air jet           | 65 | Hose             |
| 15 | Diaphragm spring            | 49 | Cold start link         | 66 | Clip             |
| 16 | Diaphragm cover             | 50 | Grub screw              | 67 | Guide clip       |
| 17 | Main jet                    | 51 | Cold start shaft        | 68 | Hose             |
| 18 | Sealing washer              |    |                         |    |                  |
| 19 | Pilot jet                   |    |                         |    |                  |
| 20 | Screw                       |    |                         |    |                  |
| 21 | Filter element              |    |                         |    |                  |
| 22 | Sealing washer              |    |                         |    |                  |
| 23 | Float valve assembly        |    |                         |    |                  |
| 24 | Float                       |    |                         |    |                  |
| 25 | Pivot pin                   |    |                         |    |                  |
| 26 | Gasket                      |    |                         |    |                  |
| 27 | Float bowl                  |    |                         |    |                  |
| 28 | Sealing washer              |    |                         |    |                  |
| 29 | Drain plug                  |    |                         |    |                  |
| 30 | Pilot screw limiter cap     |    |                         |    |                  |
| 31 | Pilot screw                 |    |                         |    |                  |
| 32 | Spring                      |    |                         |    |                  |
| 33 | Sealing ring                |    |                         |    |                  |
| 34 | Throttle lever              |    |                         |    |                  |

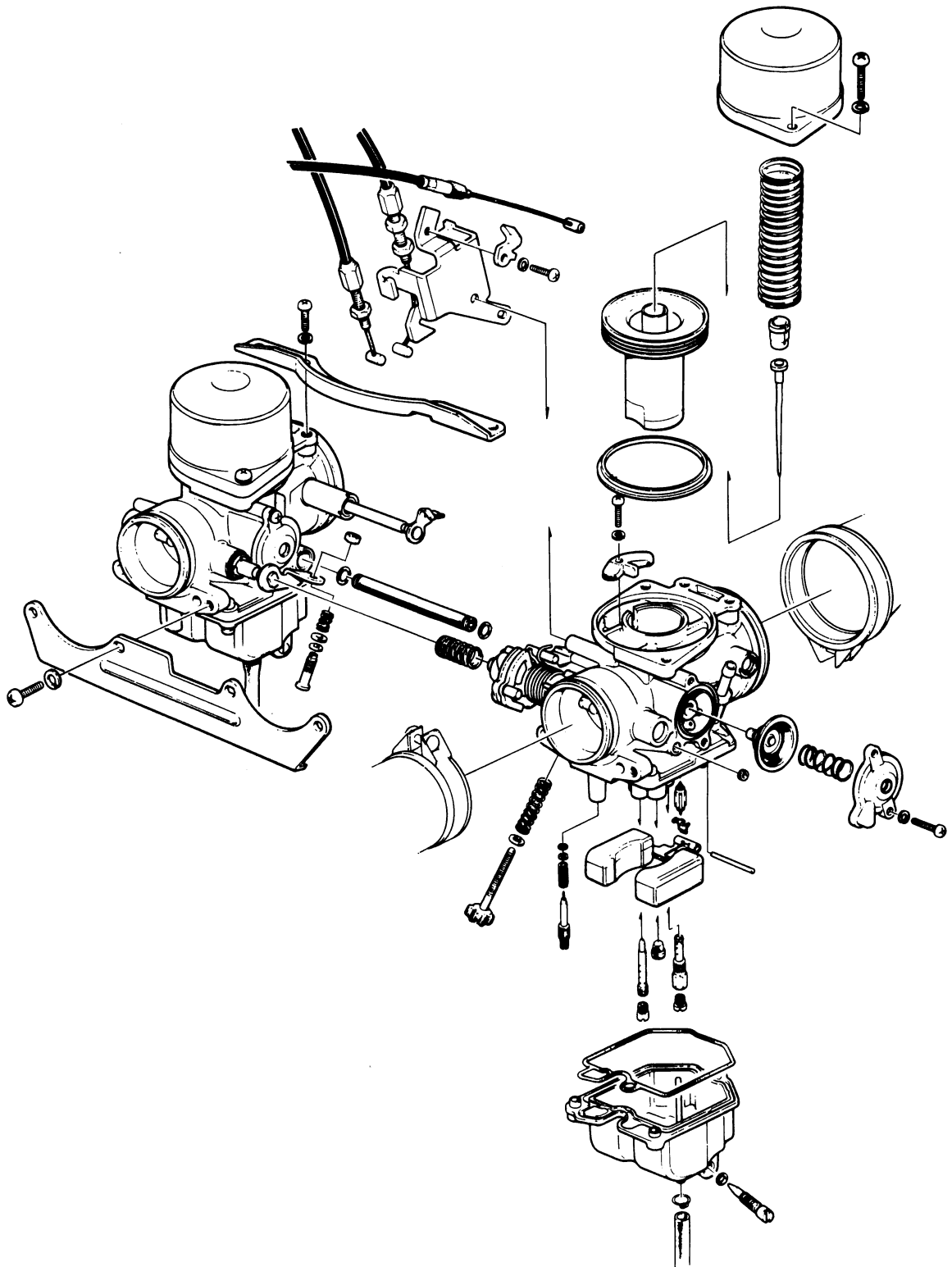


Fig. 9.10 General view of CD carburettors (SU type) fitted to Honda CX 500

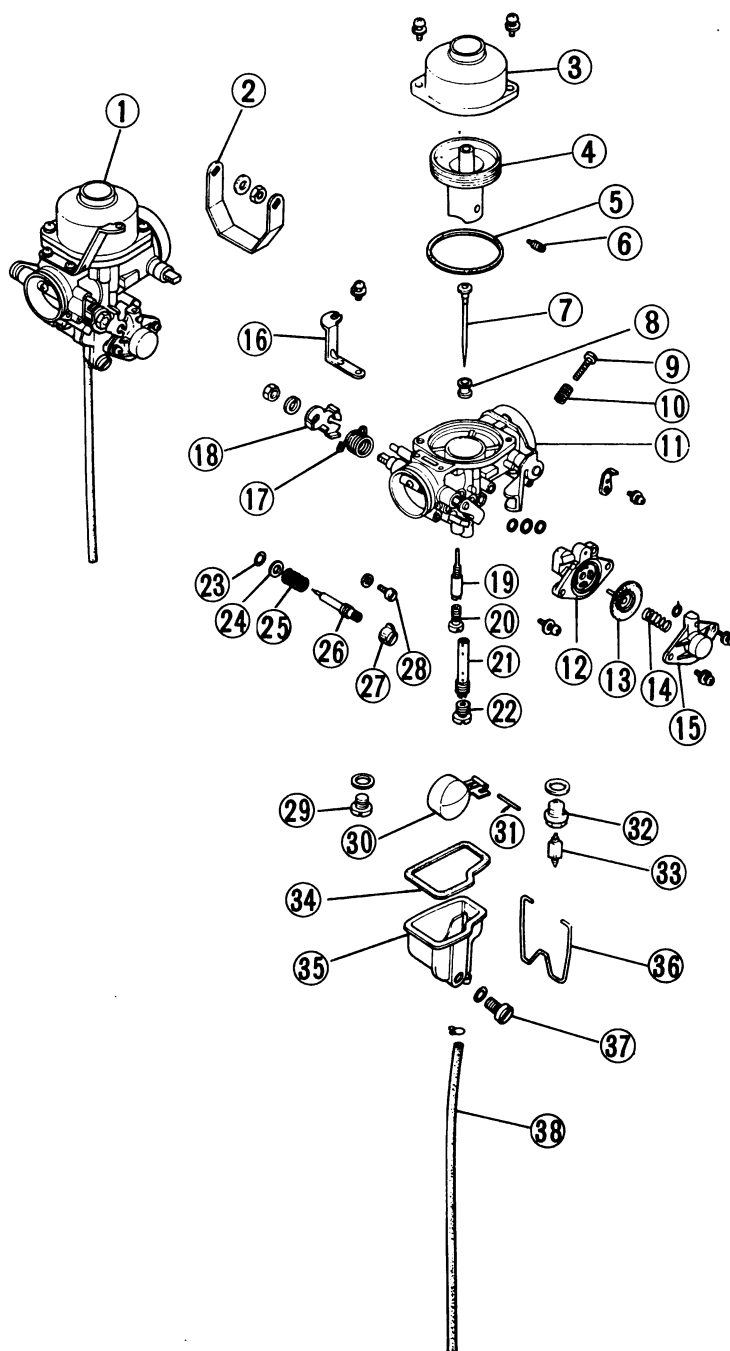


Fig. 9.11 Keihin SU-type CD carburetors – as fitted to Honda CB 500T

- |                           |                           |                                       |
|---------------------------|---------------------------|---------------------------------------|
| 1 Right-hand carburettor  | 14 Spring                 | 27 Limiter cap                        |
| 2 Connecting linkage      | 15 Cover                  | 28 Plug screw (vacuum gauge take-off) |
| 3 Vacuum cylinder         | 16 Bracket                | 29 Plug screw                         |
| 4 Vacuum piston           | 17 Throttle return spring | 30 Float                              |
| 5 Seating ring            | 18 Throttle lever         | 31 Pivot pin                          |
| 6 Needle locating screw   | 19 Slow running jet       | 32 Valve seat                         |
| 7 Jet needle              | 20 Pilot jet              | 33 Float valve                        |
| 8 Needle retainer         | 21 Needle jet holder      | 34 Gasket                             |
| 9 Throttle stop screw     | 22 Main jet               | 35 Float bowl                         |
| 10 Friction spring        | 23 O-ring                 | 36 Retaining clip                     |
| 11 Main body              | 24 Washer                 | 37 Drain plug                         |
| 12 Air cut-off valve body | 25 Friction spring        | 38 Overflow pipe                      |
| 13 Diaphragm              | 26 Pilot screw            |                                       |

### 5 Dismantling fixed-jet carburettors

The fixed-jet carburettor is essentially simple in construction, although it has a number of features which can make a full overhaul rather difficult. Most significant of these is the liberal use of Welch plugs on Tillotson instruments. These small metal discs are used to close passages off after a jet or other component has been inserted. The plugs are tapped into position, and are an interference fit in the passages into which they are inserted. The only way to remove them is to drill them out very carefully, ensuring that the component beneath the plug is not damaged. As this is a rather difficult operation, the plugs should be left undisturbed unless it is essential that they are removed. New Welch plugs should be obtained before the old ones are destroyed.

The Tillotson carburettor also employs a flexible diaphragm in place of the more common float arrangement. As fuel flows into the diaphragm chamber, the diaphragm is displaced until it closes the fuel inlet valve. Then, as the fuel level drops, the valve opens and the cycle is repeated. In this way the fuel level is maintained. The diaphragm is mounted on the underside of the carburettor, and can be removed after the cover has been released. This is retained by six screws.

On both Tillotson and Bendix instruments there is a plunger type accelerator pump. This injects a carefully set measure of fuel into the inlet tract as the throttle is opened, thus providing a temporarily richened mixture for acceleration. The plunger assembly should be removed for examination after the operating lever has been released.

The Bendix instrument has a long idler tube which screws down through the centre of the carburettor from the top. It has a round cheese-headed top and can be removed with a suitable screwdriver. The main jet is screwed into the underside of the float bowl and can be removed to allow the float bowl to be lifted away. Care should be taken not to damage the O-ring which seals the main jet assembly.

The Keihin carburettor is generally similar to the Bendix type, but does not have the long idle tube arrangement. The float bowl can be removed after its four securing screws have been removed, and the float assembly can then be dismantled. The low-speed jet, main nozzle and the main jet form an assembly which is fitted into the underside of the carburettor, directly above the float. The accelerator pump is of the diaphragm type, and is mounted on the underside of the float bowl. The diaphragm cover will lift away after its retaining screws have been released, revealing the diaphragm and spring.

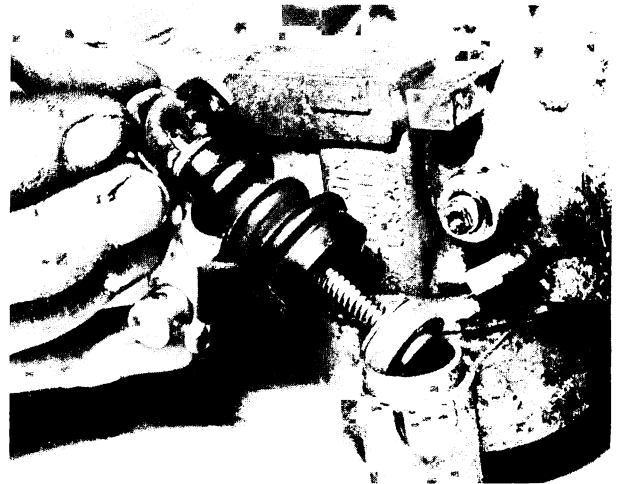
The throttles of all fixed jet types are of the butterfly type, and should not require removal. If removal does prove necessary, release the operating mechanism at the shaft end. Note the disposition of the throttle plate, then remove its two securing screws. Release the plate to allow the spindle to be withdrawn. The 'choke' valve can be dealt with in a similar manner.

### 6 Examining and renovating the carburettor components

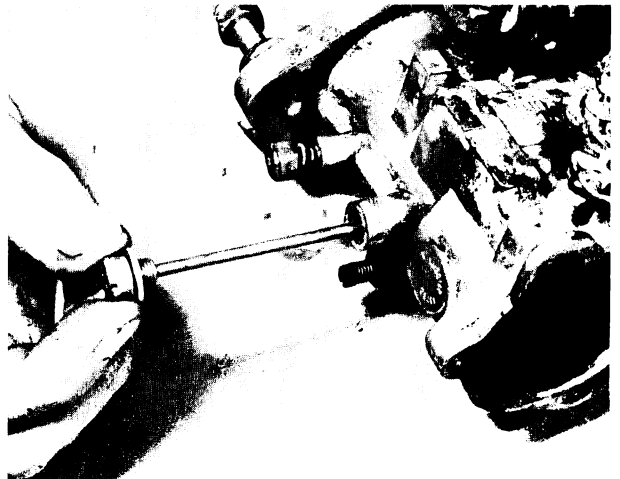
When the carburettor has been completely dismantled, lay out the components parts for examination and cleaning. These operations should be carried out together, as sediment often indicates that a problem has been caused by blockage or partial obstruction, rather than by mechanical wear or failure. For this reason, the various jets and orifices should be examined as cleaning progresses. This operation requires good lighting and a clean surface on which the various parts can be laid out after checking. A sheet of paper or clean cloth is ideal.

#### *Carburettor body, throttle valve and float bowl*

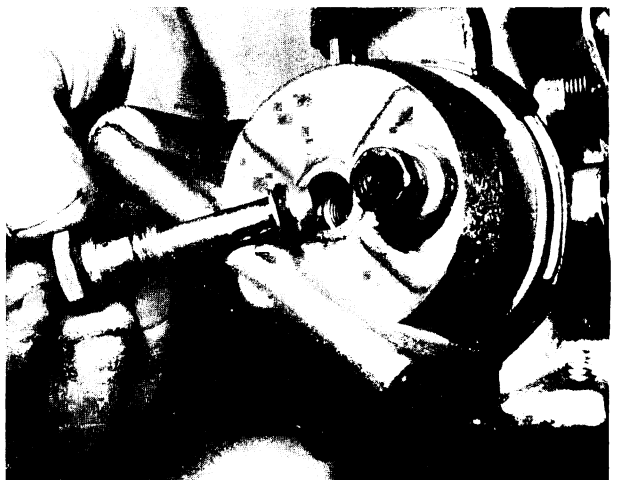
Wear in these components is only likely after very high mileages, but accelerated wear is often present in cases where no air cleaner arrangement has been used. What usually happens is that air borne dust is drawn into the carburettor and



9.47 Bendix and Tillotson fixed jet instruments employ plunger-type accelerator pumps



9.48 Bendix instrument has an idler tube in place of usual jet



9.49 Main jet assembly also secures float bowl



clings to the damp surfaces. Where there is movement, as in the case of the throttle valve and its bore, there will inevitably be wear due to abrasion. If found early enough, a new throttle valve and an air filter may be enough to resolve the problem, but if left the play between the two components will become increasingly pronounced until renewal of the carburettor body is necessary.

The problem is compounded by the pulsing effect of the air through the carburettor. This tends to hammer the valve back and forth when the engine is running, and slight play soon becomes excessive. In a sound instrument, only a very slight clearance is allowed, and should be barely detectable. If the body appears worn, try a new throttle valve before condemning the entire instrument. It must be stressed that a carburettor that is worn in this way can never be tuned properly, as it allows spasmodic air leaks to ruin the precise mixture ratio. The lesson to be learned from this sort of damage is that an air filter must **always** be fitted, and that throttle valves should be renewed as soon as wear is discovered. This is one of the few terminal carburettor afflictions.

Damage is unlikely to be found unless a previous inept owner has attacked the carburettors with the attitude and tools normally reserved for agricultural implements. It is hoped that readers of this book will apply sufficient skill and sensitivity to prevent such physical damage occurring in the course of their work.

Stripped retaining threads can often be reclaimed by tapping a new, oversize thread, and fitting a wire thread insert of the Helicoil type. Most motorcycle dealers offer a service of this type and will be able to advise whether it is practicable or not. The threads into which the jets screw are another matter, as thread inserts will allow some leakage of the fuel and/or air around the outside of the jet. Here it is necessary to seek professional advice. If part of a supporting casting is broken away, and necessity demands it, it may be possible to effect a repair with Doublebond or a similar epoxy-based filler-adhesive. This is a somewhat esoteric procedure which, if done skilfully, will produce the desired result. Conversely, done badly it will make matters much worse. The decision must therefore rest with the owner.

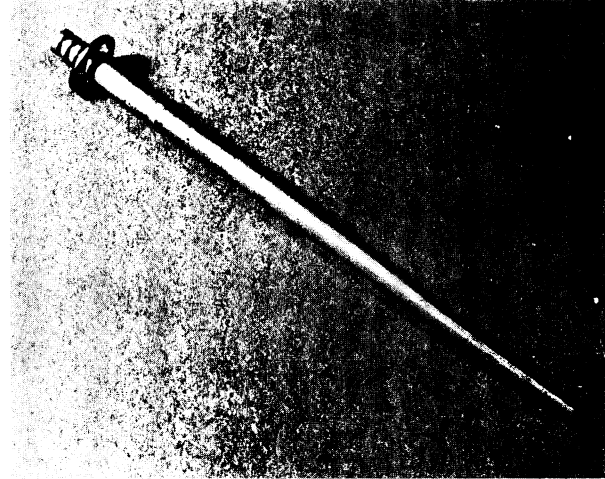
The carburettor body, and sometimes the float bowl, contains a number of passages and orifices. The former are quite large, and may be cleaned out with pipe cleaners and petrol. The orifices on the other hand are fine drillings and should never be cleared by pushing wire into them, as this will enlarge or damage them. The answer is to use compressed air, where available, or a foot pump if necessary. As a last resort, the various orifices can be cleared by using something **softer** than the casting material. This precludes most metals, and the safest alternative is a fine nylon bristle from a brush. It must be noted that the orifice need not be enlarged to ruin it – it is necessary only to scratch the bore surface to destroy its flow rate.

### *Jets and needles*

Wear in these components is very difficult to assess visually, and can only be measured by comparing the jet's flow characteristics with a new component. This is not a practical proposition for ordinary owners, because it entails the use of an accurate test rig, the cost of which can only be justified by the carburettor manufacturers and distributors. With the exception of the needle and needle jet, however, wear takes place very slowly indeed, being caused by the erosive action of fuel flowing through the jet orifice. It follows that unless the jets are quite old, they are unlikely to be worn to the extent that renewal is required.

The needle jet and needle are another matter, because the sliding metal-to-metal contact will allow wear to take place, and will substantially affect the amount of fuel flowing through the jet at any given setting. This situation is aggravated by the pulsing which takes place in the carburettor choke, and the needle and jet will wear on the sides facing along the carburettor choke. The needle provides a good indication of wear, and careful examination will reveal an uneven profile or

scratches on a damaged component. If this is evident, it can safely be assumed that the needle jet will be worn by a similar amount, and the two components should be renewed as a set. If the needle proves to be in good condition, check it for straightness before proceeding with the overhaul. This is easily accomplished by rolling it across a dead flat surface, such as a sheet of glass. Any distortion will quickly become evident.



9.50 Check needle for scoring or other damage. Renew needle and needle jet if suspect

### *The float assembly and valve*

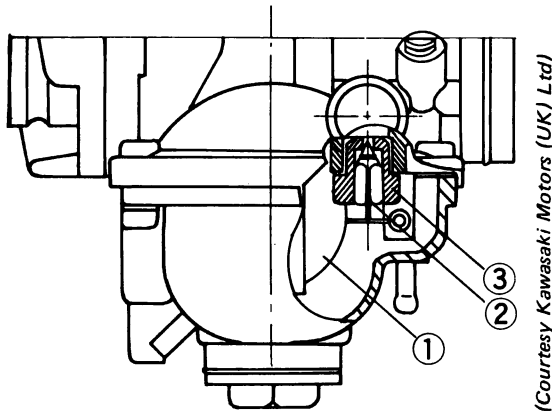
The floats should be checked for leakage by shaking them and listening for any sign of fuel inside them. Most current instruments have plastic floats, and these are unlikely to develop leaks. The older, brass floats are constructed by soldering pressed brass sections together, and these do tend to develop leaks at the joints. It should be stressed that leaking brass floats should never be re-soldered, as the fuel inside can explode quite dramatically if heat is applied. It is much safer to use an epoxy resin adhesive if repair is necessary. This should be applied thinly around the source of the leak to minimise the extra weight of the repaired item.

If it proves difficult to establish the exact position of the leak, try putting the float in very hot water. This will make the air inside the float heat up and expand, and the leak can be spotted by the trail of escaping air bubbles. Care should be taken to ensure that water does not get drawn back into the float, because this must be quite empty of fuel or water before it is sealed up. Where possible, a new float should be fitted, rather than the leaking float repaired.

The float pivot rarely wears to the extent that it causes problems. This applies equally to the operating arm of the independent float systems. If wear or damage are found it will normally be necessary to renew the arm or float assembly, as the pivot points are an integral part of this.

The float valve will eventually wear and permit leakage, and this can seriously affect the operation of the carburettor by causing flooding at low engine speeds. The tapered tip of the needle will show signs of wear first, and should be examined very carefully. If worn, and requiring renewal, it is advisable to enquire whether a synthetic rubber-tipped needle is available on instruments having a nylon or brass needle. The rubber-tipped variety are far less prone to leakage, do not wear out the valve seat, and being resilient, will resist the effects of vibration very well.

On most carburettors, the needle valve seat is detachable, and thus can be renewed if necessary. On a few instruments, notably Amal, the seat is integral with the carburettor float bowl casting. Wear will normally demand renewal of the casting, but try fitting a new needle first, because this is considerably less expensive, and may well prove effective.



(Courtesy Kawasaki Motors (UK) Ltd)

Fig. 9.12 Float mechanism overhaul

The float needle valve (2) and seat (3) are prone to wear or contamination. Float (1) will allow flooding if leaking.

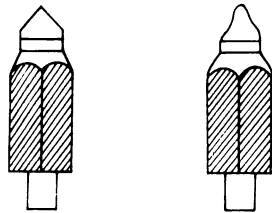


Fig. 9.13 Checking float valve for wear

A sound float valve needle is shown on the left. The worn item on the right will allow flooding, causing erratic running and poor fuel consumption

#### Diaphragm – Stromberg type CD instruments

The diaphragm is a thin synthetic membrane which forms an air-tight seal between the suction chamber above the piston (valve) and the outside atmospheric pressure. It is flexible to allow the valve to rise and fall without presenting any noticeable resistance. It will be obvious that any leakage will seriously affect the operation of the carburettor, because an air leak past the diaphragm will prevent a depression being formed in the suction chamber. The diaphragm should, therefore, be examined very carefully for signs of splitting, and renewed if in dubious or damaged condition.

Unlike car carburettors of this type, the diaphragm is not normally available as a separate item, and is considered to be 'integral' with the valve. It follows that it will be necessary to renew both components if one is worn or damaged. When fitting the diaphragm/valve assembly back into the carburettor, ensure that the lip around the edge of the diaphragm seats squarely in its recess to avoid air leaks. It will be noted that the diaphragm has a small locating tab which must engage with a corresponding recess in the carburettor body.

The return or damping spring, where fitted, is unlikely to require renewal unless accidentally bent or distorted. It is important that the spring remains straight and even, as deformities will affect the rate at which the valve opens and closes in response to various engine speeds. If in doubt, take the spring and compare its length with that of a new component, or if spring length figures are available, check it against these.

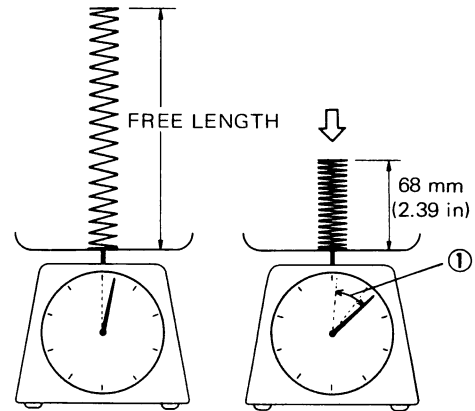


Fig. 9.14 Checking piston valve return spring pressure

Given the appropriate data, the piston valve return spring can be checked by measuring its tension at a prescribed amount of compression.

#### Piston – SU type CD instruments

The piston on these carburettors should not wear in normal use, because it does not touch the walls of the vacuum cylinder. Wear may be present on the lower surfaces, however, because this behaves in the same way as the throttle valve in a slide carburettor. It is important to check that the piston moves smoothly in the vacuum cylinder, because any resistance or tight spots will have a marked effect on performance. This can be checked with the carburettor assembled by lifting the bottom of the piston via the main bore of the carburettor. When released, the piston should descend smoothly and cleanly until it reaches its stop, or, when fitted, the damping ring.

The needle on this type of carburettor is usually clamped in position by a grub screw through the side of the piston, the screw bearing upon a needle retainer. The needle should be released and checked for wear in the same way as that described for slide carburettors.

#### Fixed jet carburettors – additional notes

Fixed jet instruments are comparatively unusual on motorcycles, and are only likely to be encountered on Harley-Davidson machines. Most of the foregoing comments can be related to these instruments but major procedural differences are listed below.

The Tillotson instruments used up to 1971 were unusual in that they employed a diaphragm arrangement in place of the more conventional float chamber. This system has an advantage in that it is less easily upset by fuel surge and the resultant frothing of fuel. The diaphragm is similar to that used in CD instruments (though for a different purpose) and can be treated in a similar manner. Diaphragm leakage will lead to flooding and will have a marked effect on performance, so care must be taken to ensure that the diaphragm assembly is sound. The diaphragm inlet valve is similar in operation to a float valve arrangement, but tends to be rather complicated to deal with, having numerous parts when compared with the conventional float type. Care should be taken not to lose these.

Where detent balls and springs are encountered, as on the Tillotson HD carburettor's cold-start or 'choke' shaft, check that the recess in which they operate is clean and allows free movement of the ball. The ball should be free from blemishes or rusting, but requires little attention normally. This applies to the accelerator pump main nozzle and economiser check valve balls. None require specific maintenance, but must be kept absolutely clean.

Some of the jets are retained by Welch plugs, as is the small economiser check valve. If it is absolutely necessary to remove these plugs, make sure that new plugs are to hand before removing the old items by carefully drilling them out.

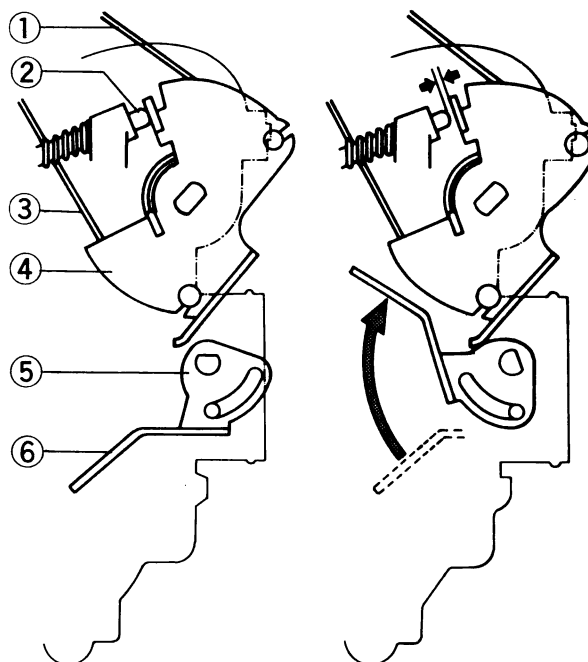
(Courtesy Kawasaki Motors (UK) Ltd)

Take great care not to drill into the carburettor casting during this operation. The new Welch plugs can be fitted by carefully tapping them into place, using a suitable flat-ended drift. Carefully drive the plug inwards until it **just** seats, but be very careful not to burr the softer metal of the bore during fitting.

The Bendix and Keihin fixed jet carburettors employ conventional float systems, and can be dealt with in the manner described earlier in this Chapter. It will be noted that the Bendix type has a light return spring which should be assembled in the same position that it occupied prior to removal.

Tillotson and Bendix instruments have a plunger-type accelerator pump arrangement, whilst that of the Keihin is of the diaphragm type. These can be checked for obvious signs of wear, but little can be done to assess their performance. Fortunately, they are not prone to malfunctions, and usually either work properly or not at all. A rough check of their operation can be made by connecting up a fuel supply and observing the stream of fuel injected into the choke when the throttle is opened. This should be fairly consistent, and as long as this is the case, the pump can be assumed to be working effectively. If not, try renewing the plunger cup or diaphragm as appropriate.

In most other respects, overhaul of the Keihin and Bendix instruments is straightforward, and does not involve the rather fiddly Welch plugs of the Tillotson. The throttle butterfly valves are of the same type used on CD instruments, and are not normally prone to wear. As mentioned previously, air leaks may develop around the spindles of very old instruments, but this is fortunately rare. If present, borin out and bushing is the only alternative to a new carburettor body, but this is specialised work and must be entrusted to an engineering company or a similar expert.



(Courtesy Kawasaki Motors (UK) Ltd)

Fig. 9.15 Fast idle mechanism

Some machines, like the Kawasaki KL250, have a fast idle mechanism. A cam profile (5) on the cold-start lever (6) bears on a stop on the throttle pulley (4). In the second illustration, the throttle has been opened slightly. The gap at (2) should be at the prescribed setting.

## 7 Rebuilding the overhauled carburettor

After thorough cleaning and examination, lay out the components of the carburettor on a clean surface. Before assembly can commence, it will be necessary to have a set of new gaskets and seals to hand. In some cases, the original items can be re-used, but it is better to err on the side of caution and fit new parts.

The assembly operation is a reversal of the dismantling sequence, and should not present too many problems. It is useful to have an exploded view of the instrument if possible, as this will allow the correct relative position of the various parts to be checked. The most important point is to avoid over-tightening any component, because the jets and threads are relatively soft and easily damaged. Ensure that all seals and O-rings are in the right position and seat securely. Linkages and butterfly spindles should be lubricated with thin machine oil during installation, but keep this away from the jets and orifices, because the relatively heavy oil can block the smaller openings.

On slide and CD instruments, check that the throttle valve or piston moves smoothly and returns fully when released. The consequences of a sticking valve are not at all pleasant if encountered in heavy traffic. The various marked jets and needles should be checked with those prescribed by the manufacturer, and replaced if incorrect. Tuning should always start with the original specified settings.

On instruments with float valve arrangements, the fuel level or float height must be checked before the carburettor is refitted. Details of this procedure are given in the tuning chapter related to the carburettor in question. Pilot mixture screws should be set at the prescribed nominal position until tuning confirms that this position is correct or proves otherwise.

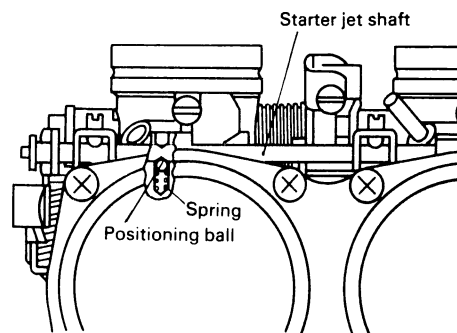


Fig. 9.16 Cold-start shaft detent arrangement

Some form of detent is frequently used on the cold-start shaft to give a positive on-off position. Make sure that the ball and spring are not lost when the shaft is withdrawn.

# Chapter 10

## Design Variation and Ancillary Components

### Contents

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### 1 Introduction

So far, this book has dealt with carburettors by separating them into the three basic types; slide, constant depression and fixed venturi. With the exception of the latter, which has never become properly established as a motorcycle instrument, there are literally hundreds of examples of each produced by various manufacturers throughout the world. Each of these basic types can be broken down still further into the numerous models adapted to suit a particular machine. Added to this is the tendency of motorcycle manufacturers to revise the jetting arrangements for a particular model at yearly, or even shorter, intervals.

The result of this is thousands of permutations, and for this reason any attempt to cover each one specifically in one book is clearly futile. Instead, this Chapter will discuss some of the variations commonly found in carburettors of different types. In addition, those ancillary components, which are important to the correct functioning of carburation, will be investigated.

### 2 Moped carburettors

The Moped owes its existence to a demand for cheap, simple and economical transport, a role which it fulfils quite neatly. Most of these machines employ very simple two-stroke engines, generally of about 50 cc displacement and, with the exception of the European fashion for 'sports' mopeds, are little more than motorised bicycles.

It follows that the carburettor fitted to an engine of this type should be similarly small and simple. The Italian Dellorto SHA type is representative of the sort of instrument fitted by most moped manufacturers. It is a slide carburettor of simple concentric design, and resembles its larger and more sophisticated contemporaries to a marked degree. Notable for its absence is the throttle needle, which is not essential for so simple an application. The throttle valve is of the guillotine slide type, and is operated via a control cable and twistgrip. A single, main, jet is fitted, whilst the idle system is a non-adjustable arrangement of carefully sized drillings. In fact, the moped carburettor is as close as it is possible to get to the basic theoretical instrument discussed at the beginning of the book.

Tuning and maintenance could not be more simple. There is only one adjustment screw, this being a throttle stop adjuster to provide a means of correcting the idle speed. The single jet can be removed for cleaning after releasing the float bowl. The float

arrangement is a smaller version of the normal type. Cold starting is catered for by a simple shutter which partially obstructs the main choke of the instrument. On some versions a simple cam arrangement is used to retract the shutter when the throttle is opened fully, making the system semi-automatic in use.

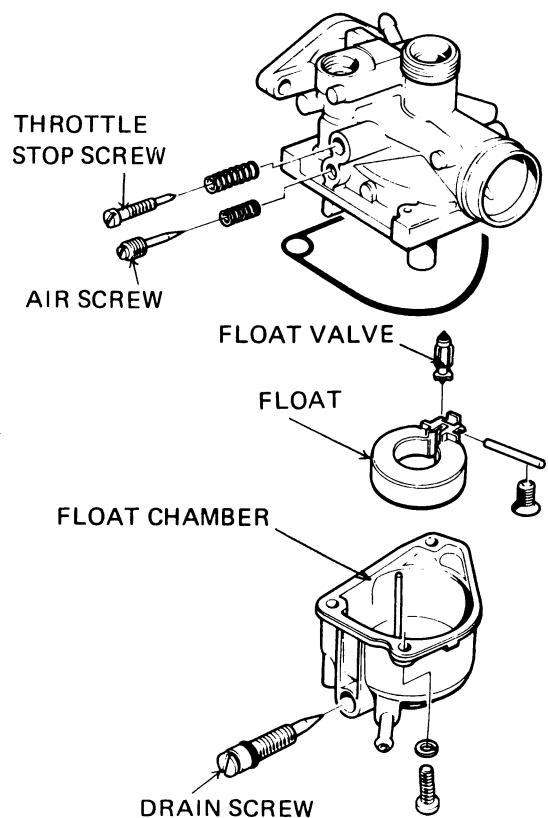
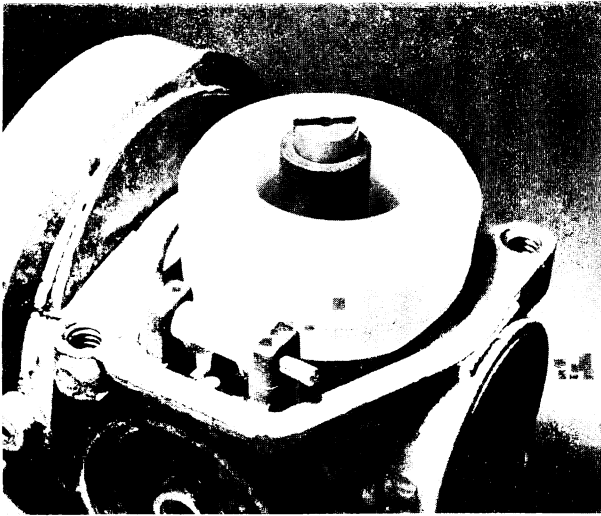
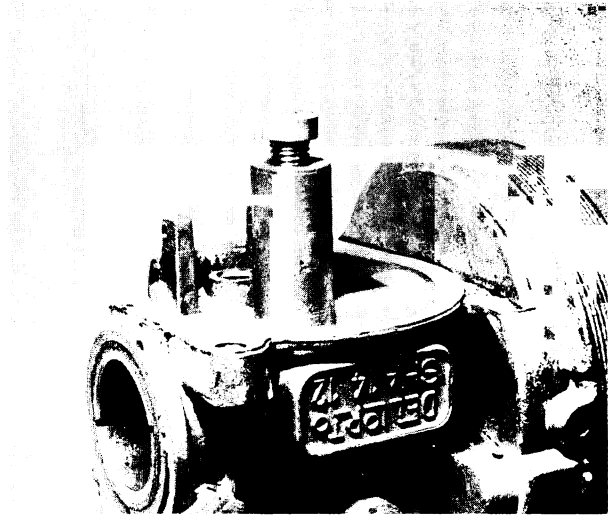


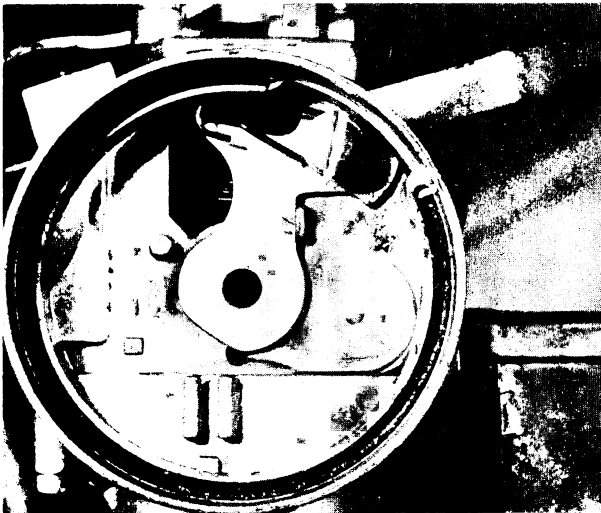
Fig. 10.1 Honda Express carburettor – note similarity with European moped instruments



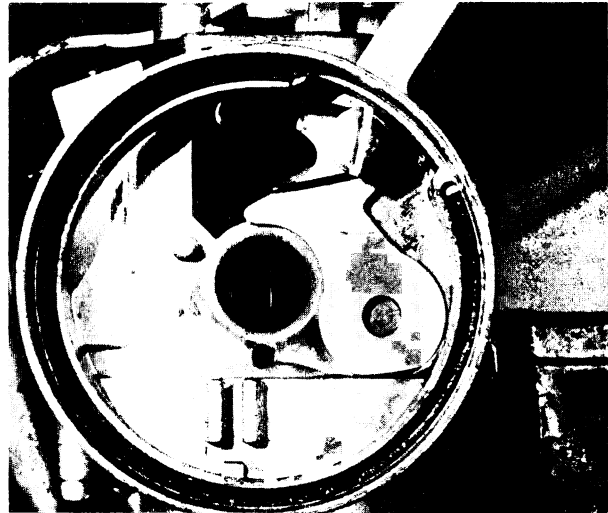
10.1 Dellorto SHA carburettor has annular plastic float



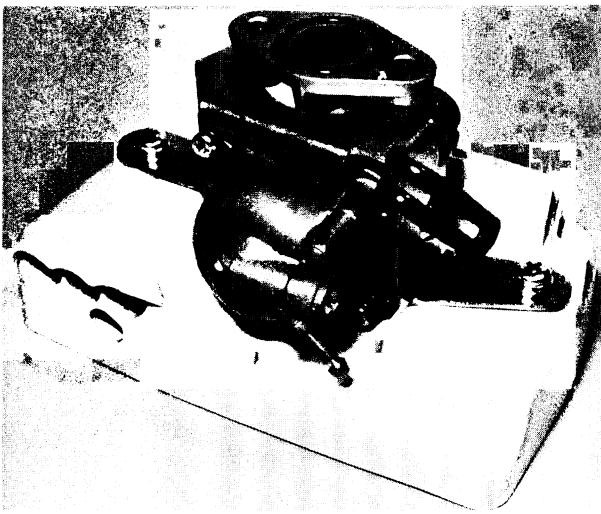
10.2 A single, main, jet is fitted



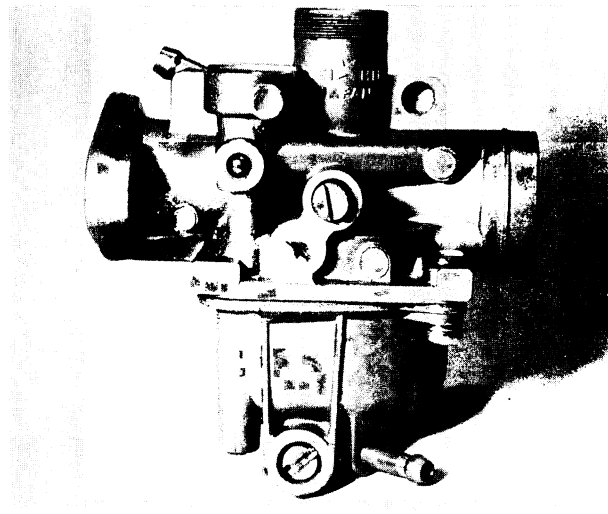
10.3 The simple shutter choke partially blocks the main bore for cold starting



10.4 When throttle is opened, choke is returned to off position by spring



10.5 Carburettor and air filter – Honda Express moped



10.6 Honda, like the other moped manufacturers, keep their carburetors simple and compact

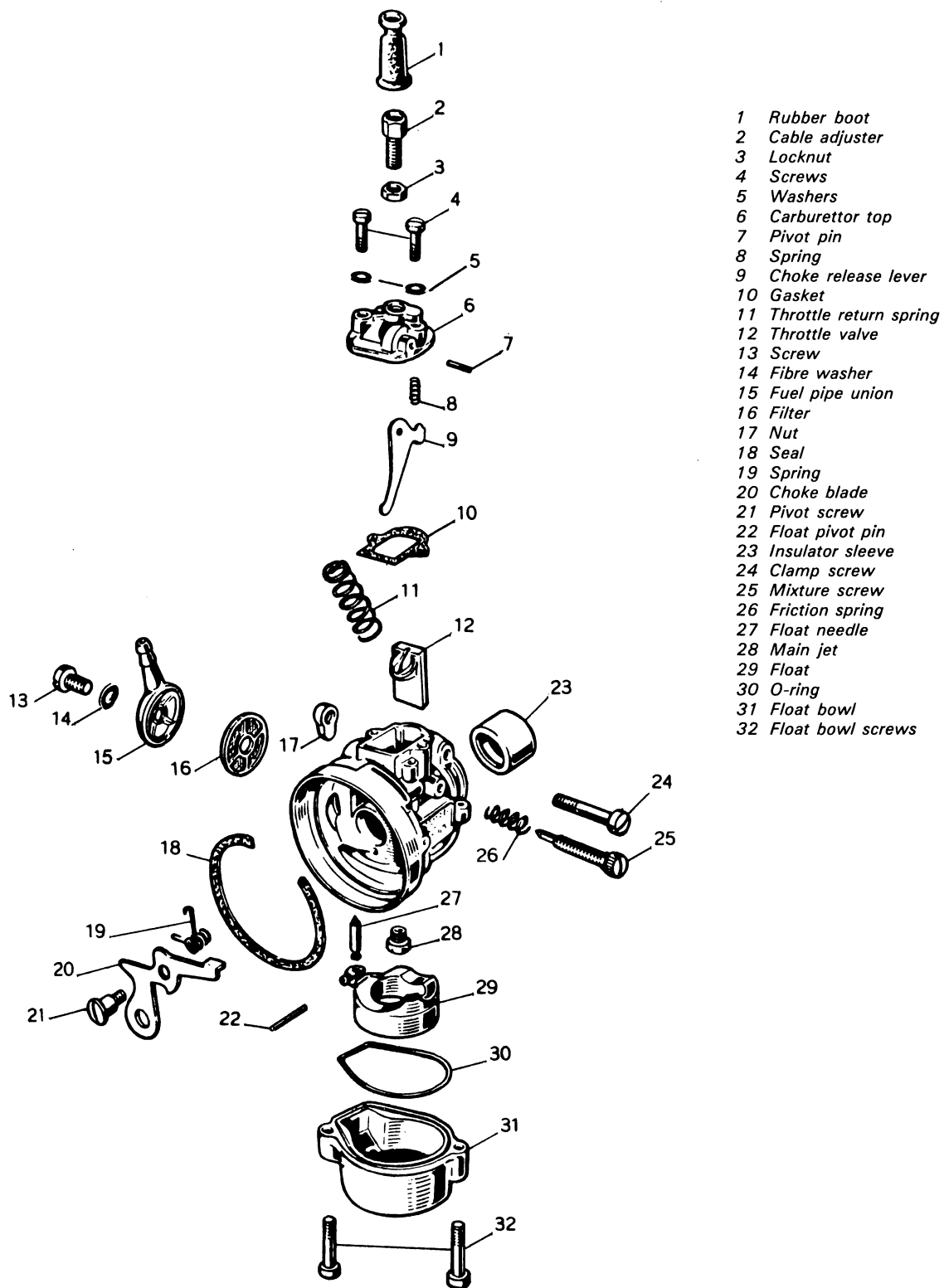
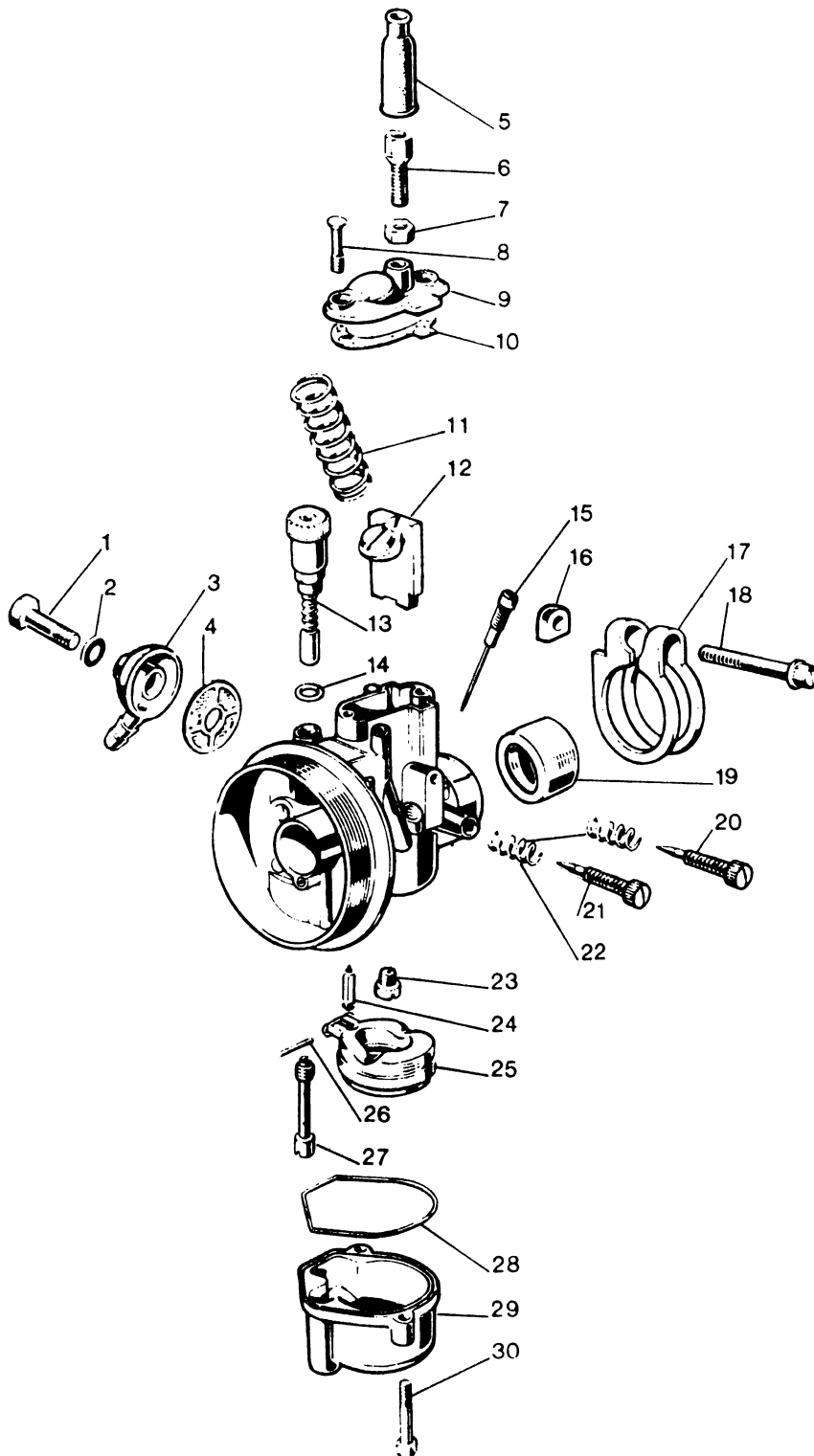


Fig. 10.2 The Dellorto SHA type moped carburettor



- 1 Screw
- 2 Fibre washer
- 3 Fuel filter
- 5 Dust seal
- 6 Cable adjuster
- 7 Locknut
- 8 Screw
- 9 Carburettor top
- 10 Gasket
- 11 Throttle return spring
- 12 Throttle slide (valve)
- 13 Cold start plunger
- 14 O-ring
- 15 Needle jet
- 16 Special nut
- 17 Clamp
- 18 Clamp screw
- 19 Insulation sleeve
- 20 Throttle stop screw
- 21 Mixture screw
- 22 Friction spring
- 23 Main jet
- 24 Float needle
- 25 Float
- 26 Float pivot pin
- 27 Emulsion tube
- 28 O-ring
- 29 Float bowl
- 30 Screw

Fig. 10.3 The Dellorto SHB type moped carburettor

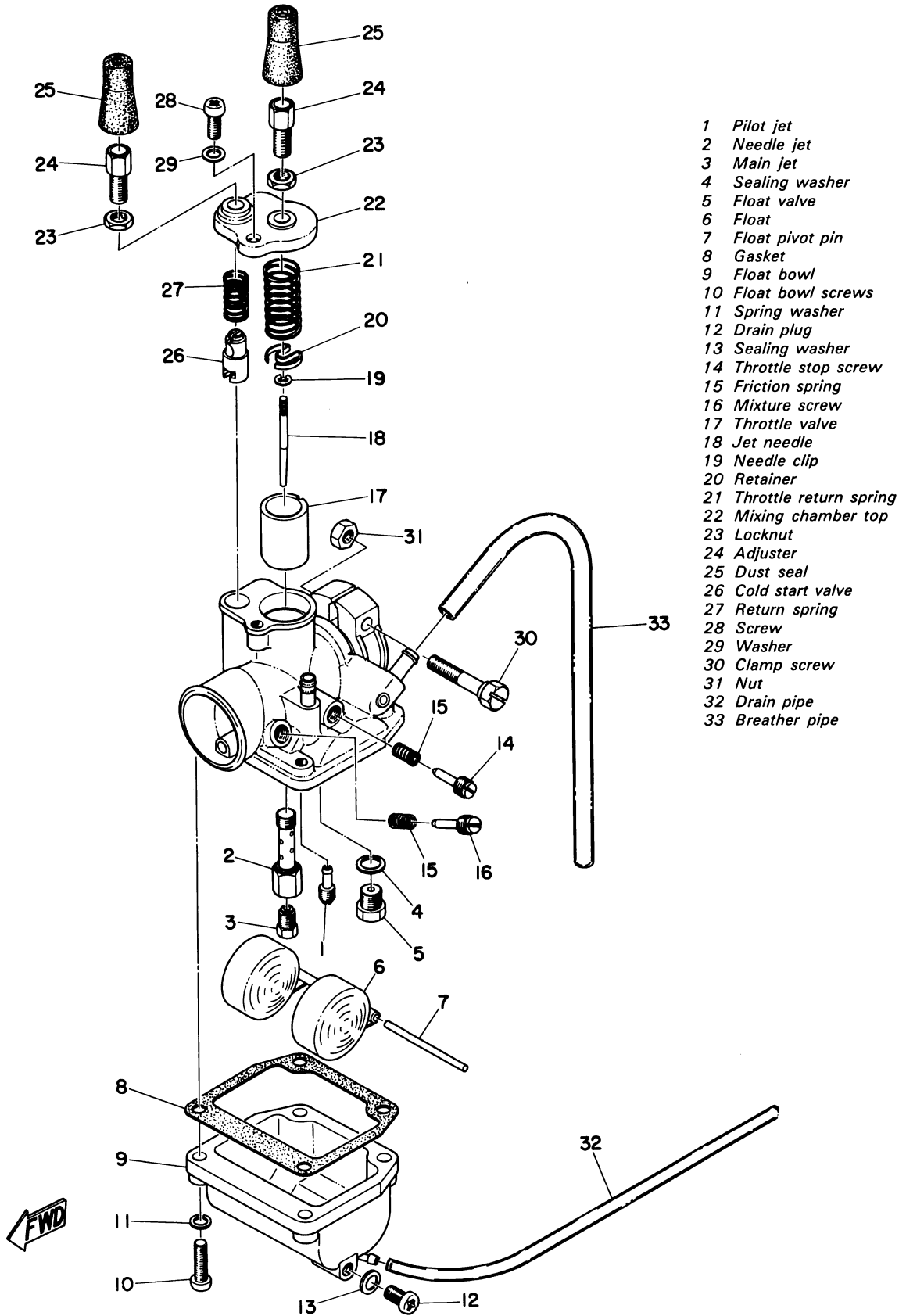


Fig. 10.4 Yamaha V70/V90 step-through carburettor

Note how this carburettor follows motorcycle design on a small scale, rather than typical moped layout



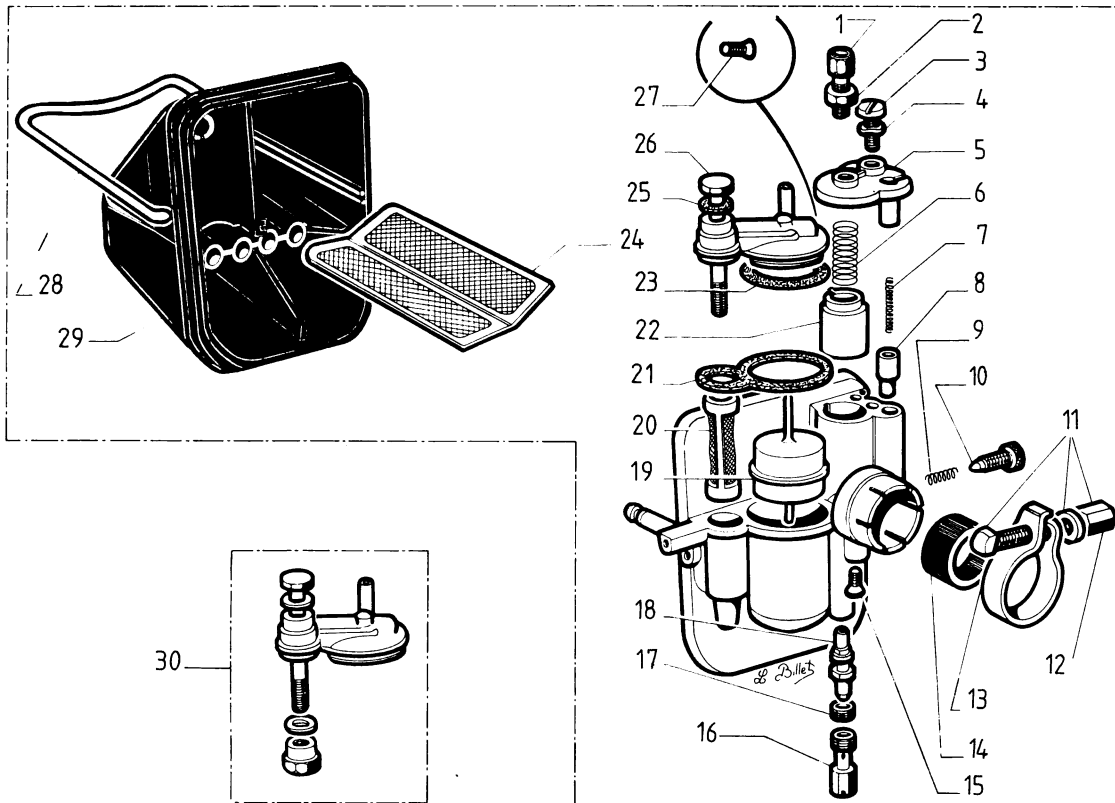


Fig. 10.5 Gurtner carburettor as fitted to Mobylette mopeds

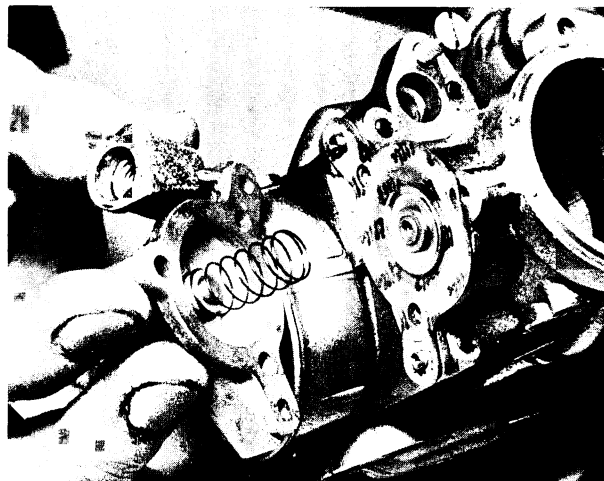
- |                           |                        |                   |                    |
|---------------------------|------------------------|-------------------|--------------------|
| 1 Throttle cable adjuster | 9 Friction spring      | 17 Ring           | 24 Air filter      |
| 2 Locknut                 | 10 Throttle stop screw | 18 Needle jet     | 25 Fibre washer    |
| 3 Screw                   | 11 Mounting clamp      | 19 Float          | 26 Screw           |
| 4 Washer                  | 12 Clamp bolt          | 20 Fuel filter    | 27 Screw           |
| 5 Carburettor top         | 13 Nut                 | 21 Gasket         | 28 Clip            |
| 6 Throttle return spring  | 14 Insulator sleeve    | 22 Throttle valve | 29 Air filter case |
| 7 Choke spring            | 15 Screw               | 23 Gasket         | 30 Carburettor top |
| 8 Choke plunger           | 16 Main jet            |                   |                    |

### 3 Accelerator pumps

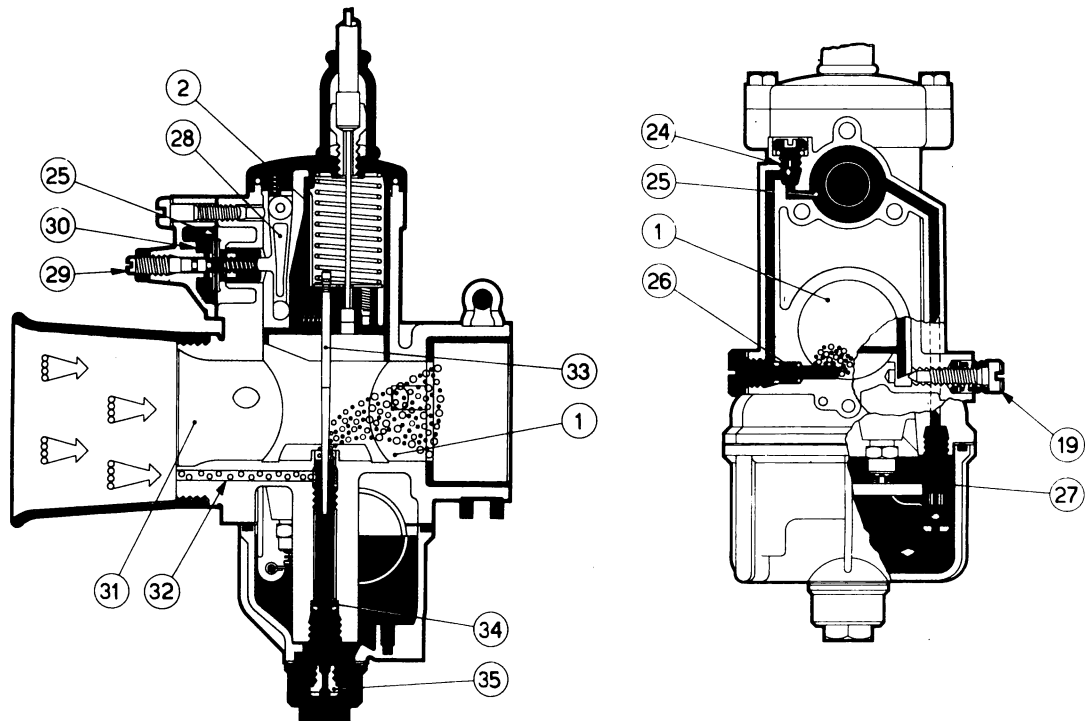
Accelerator pumps are to be found on almost all fixed venturi carburettors, and on certain slide instruments. Most common amongst the latter are the Dellorto PHF and PHM types, to be found on the larger Italian motorcycles and on certain BMW machines.

On Dellorto instruments, the pump is of the diaphragm type, and is housed in a chamber on the side of the mixing chamber. The pump diaphragm is actuated by a small cam incorporated in the throttle valve. As the throttle valve opens, the cam bears on a spring plunger in the mixing chamber wall, which in turn displaces the diaphragm. The diaphragm's movement forces fuel through a passage in the body to the pump jet, where it is sprayed into the main bore. A one-way valve in the diaphragm body opens as fuel is forced down to the pump jet, closing under gravity as the diaphragm moves back to its normal position. This action opens an inlet valve in the float chamber, drawing a fresh charge of fuel up to the diaphragm chamber.

The purpose of the pump is to automatically enrich the mixture during acceleration, and its effect is most pronounced when the throttle is opened rapidly through the lower gears. Its use does not, as is often supposed, make the carburettor less economical. On the contrary, there is no need to err on the side of excess richness of the jetting in order to obtain a surplus of fuel for acceleration.



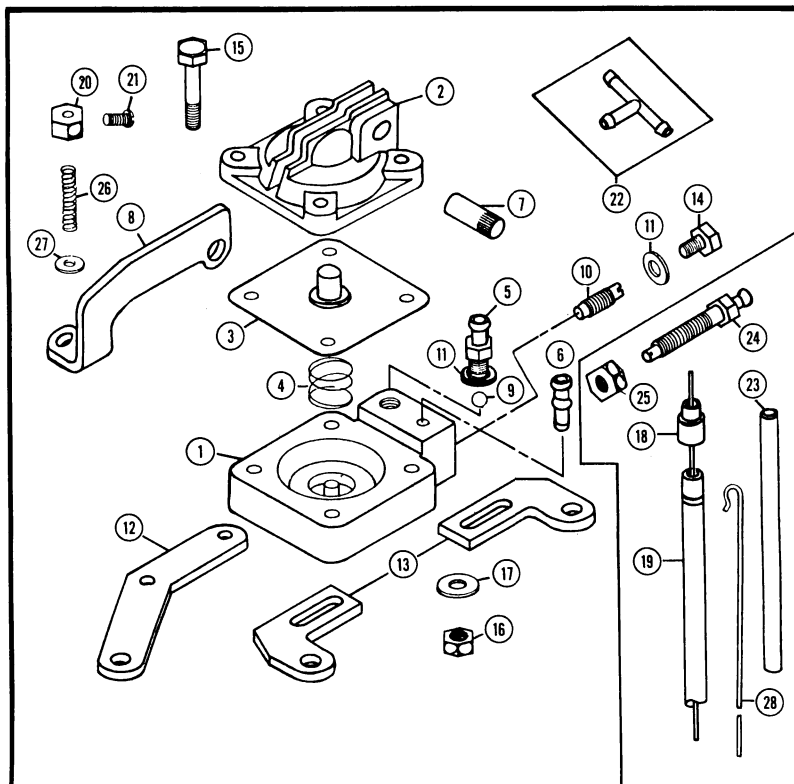
10.7 Dellorto accelerator pump is housed on side of the main carburettor body



**Fig. 10.6 Accelerator pump operation – Dellorto**

As the throttle valve (2) rises, the pump lever (28) is displaced, pushing the pump diaphragm (25) outwards. Fuel in the diaphragm chamber (30) is forced past the non-return valve (24) and is sprayed into the main bore via a discharge jet (26).

When the throttle is closed, the diaphragm returns under spring pressure. The non-return valve (24) closes, and the inlet valve (27) opens, allowing a fresh charge of fuel to enter the diaphragm chamber. The pump can be set by moving the adjuster (29) to give the required amount of fuel.



- 1 Pump body
- 2 Pump cover
- 3 Diaphragm
- 4 Return spring
- 5 Valve seat
- 6 Nozzle
- 7 Pin
- 8 Arm
- 9 Ball
- 10 Valve
- 11 Washer
- 12 Bracket
- 13 Brackets
- 14 Bolt
- 15 Nut
- 16 Nut
- 17 Washer
- 18 Ferrule
- 19 Cable
- 20 Cable stop
- 21 Screw
- 22 T-piece
- 23 Fuel pipe
- 24 Nozzle
- 25 Nut
- 26 Spring
- 27 Washer
- 28 Rod

**Fig. 10.7 An add-on accelerator pump kit for Mikuni carburetors**

The pumps used on Dellorto carburettors are adjustable, as are some of the other diaphragm types. Adjustment is made by altering the position of a grub screw which passes through the diaphragm cover, after releasing the locknut which secures it.

To check the accuracy of the pump setting it is necessary to take a precise measurement of the amount of fuel delivered during each stroke. This is accomplished by using a specialised test rig in which the carburettor is set up with a fuel supply. The throttle is opened and closed a specific number of times, and the ejected fuel is collected in a measuring cylinder.

This sort of apparatus can be approximated at home without too many problems, but the various manufacturers rarely give the recommended delivery volumes for particular models. It follows that, unless this information can be gleaned from a helpful dealer, it will be necessary to have the throttle pump(s) set up professionally.

Mikuni and some other Japanese carburettor manufacturers are now starting to fit accelerator pumps to their variable venturi models, and it is likely that this added sophistication will become commonplace in the next few years. As increasingly stringent emission laws come into operation, it is becoming more difficult for the carburettor to deliver power, economy and clean exhaust gases, because these requirements conflict to some extent. By using accelerator pumps, the carburettor can be jetted weaker overall, giving generally cleaner combustion, but retaining acceptable performance.

So far, the trend has been to fit a single pump, operated by one carburettor but feeding all four cylinders. This practice will most likely be continued, because it saves a considerable amount of extra manufacturing cost, and makes for simpler maintenance. At present, few machines from Japan have accelerator pumps as standard equipment, but Mikuni produce an 'after market' kit for single, twin, three and four cylinder engines. This arrangement bolts on beneath the float chamber, and is operated by cable or linkage from the carburettor. Fuel is pumped via flexible pipe(s) to the atmospheric side of each instrument where it is sprayed into the main choke.

A diaphragm pump is fitted to the Keihin fixed-venturi carburettor used by Harley-Davidson, though its Bendix and Tillotson predecessors employed plunger pumps. As the diaphragm type is cheaper to manufacture and less prone to wear, it is likely that this will be the subject of future developments.

The recently launched Honda four cylinder DOHC models are fitted with constant depression carburettors, each of which is fitted with a diaphragm pump of the Dellorto type.

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#### 4 Float systems and baffles

Early carburettors suffered many problems from fuel surge and the resultant temporary fuel starvation, mainly because the float chamber was remote from the main jet assembly. This problem was largely resolved by the adoption of concentric construction principles in which the main jet was at the centre of the float bowl, and thus escaped all but the most severe surge problems.

There are a number of ways of dealing with the remaining problems of fuel surge, which have become increasingly more severe as off-road and competition machines have evolved. The Amal solution was elegantly simple and commendably cheap. They merely fitted a fine gauze filter, in the form of a 'thimble' around the main jet. This will contain a small reserve of fuel to keep the engine running in the event that the main content of the float bowl is temporarily flung clear of the jet.

A similar system has been chosen by Mikuni for their competition carburettors. In this case, an inverted cup is fitted around the jet, and the assembly arranged to project into the large, hollow float bowl drain plug. The general 'sloshing' of fuel in the float bowl is minimised by fitting a flat baffle plate at the normal fuel level.

The most sophisticated solution so far is the independent

float system. Two circular floats are supported on pins projecting from the base of the float chamber. Each is free to move up and down, and either can operate the lever arm which takes the place of the conventional float pivot. This type of float system is widely used on motocross, enduro and trail machinery, where it helps the carburettor to cope with the uneven terrain.

The arrangement poses no particular problems when tuning or overhauling this type of carburettor. The floats can be slid off their support pins, if required, usually after small plastic retainer caps have been removed. The forked lever arm is dealt with in the same way as the pivot assembly in conventional arrangements.

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#### 5 The Lectron carburettor

This instrument is produced as an after-market item in the USA, where it has gained something of a following by virtue of its unorthodox design.

The Lectron instrument is a modern concentric design slide carburettor. A guillotine type throttle valve is used, and an independent float system is housed in a transparent plastic float bowl. More significantly, the Lectron uses no main jet, pilot jet, jet needle or needle jet, these being replaced by a single metering rod which is fitted in place of the conventional needle.

The metering rod is a parallel needle with a fine thread at its upper end, and a carefully machined flat on one side. The rod runs in a close-fitting orifice, through which fuel is drawn from the float bowl. As the throttle slide is lifted, the amount of obstruction offered by the rod in its bore is reduced, allowing a progressively higher rate of fuel flow into the choke.

The precisely machined metering rods are available in a range of sizes giving various mid-range and full-throttle mixture combinations. The rods are indexed with two numbers, the first denoting full throttle mixture, and the second mid-range mixture. When tuning is required, the mixture strength at various throttle settings is assessed in the usual way, and a metering rod with the appropriate characteristics is selected. Idle mixture strength is adjusted by moving the needle one turn higher or lower in relation to the throttle slide. It is then secured by a grub screw.

---

#### 6 Air filters

Nearly every current production motorcycle is equipped with some means of filtering the air entering the carburettor, and the effectiveness of the filter has a very significant effect on engine performance and life. The filter element is required to trap the smallest dust particles without causing a severe restriction in air flow or occupying too much space.

A few machines make use of a pleated paper element. This consists of a band of porous paper which is pleated to allow a large surface area to be fitted into a reasonably small case. To protect the element from moisture contamination, it is often impregnated with resin. This strengthens the paper and gives it a degree of water resistance.

Paper elements are best kept clean by removing them from the air cleaner casing and tapping them on a hard surface to dislodge the accumulated dust. This is usually sufficient, but it is helpful to brush off obvious patches of dust using a dry paintbrush. If an air line is available, compressed air can be directed through the filter in the opposite direction to normal airflow.

As the element ages, the pores in the paper surface will gradually become permanently blocked, and eventually it will be necessary to renew it, usually after about six cleanings. Care must be taken to keep the element free from oil or water, because these will quickly ruin it. When the element is removed for cleaning it should be examined carefully for signs of damage. Any splits or holes will necessitate the filter's prompt renewal.

Oil-impregnated foam elements are used on a wide range

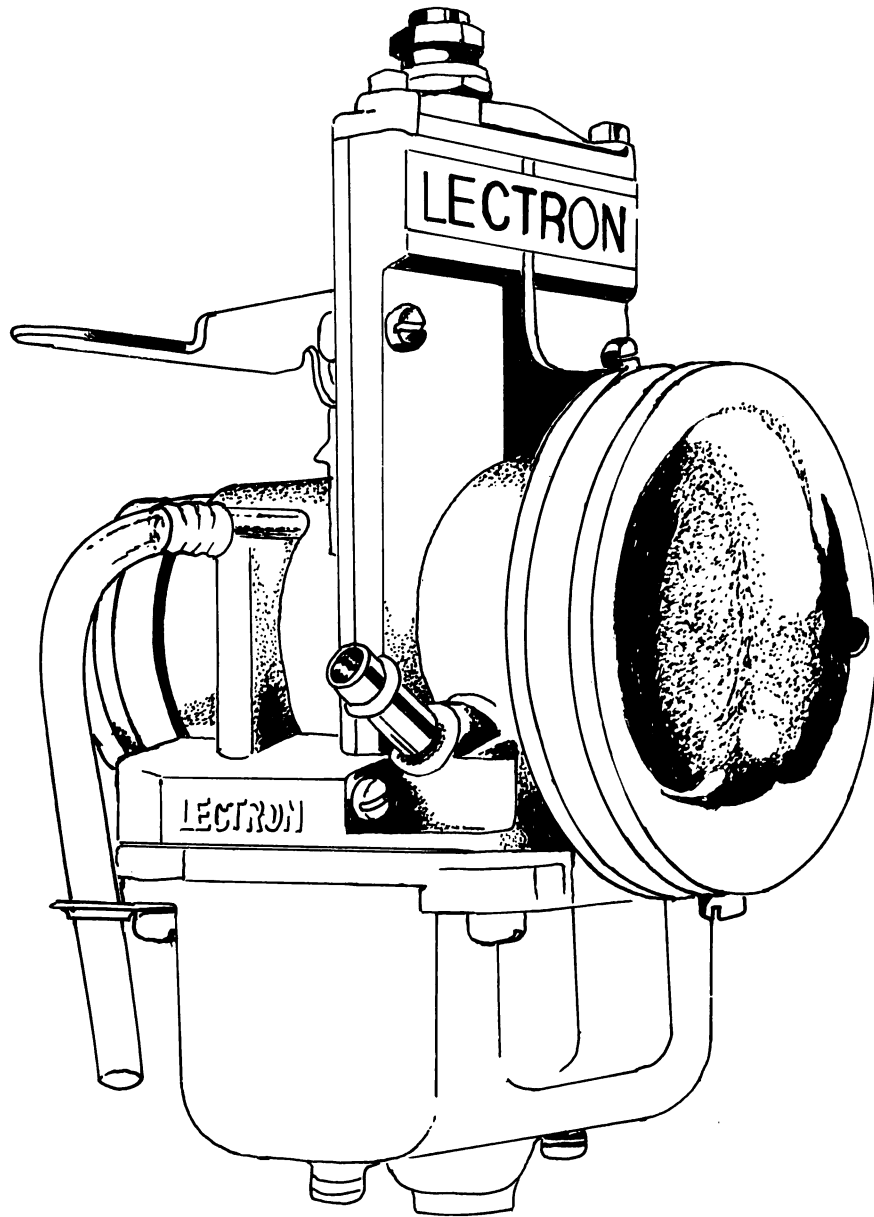


Fig. 10.8 The Lectron carburettor

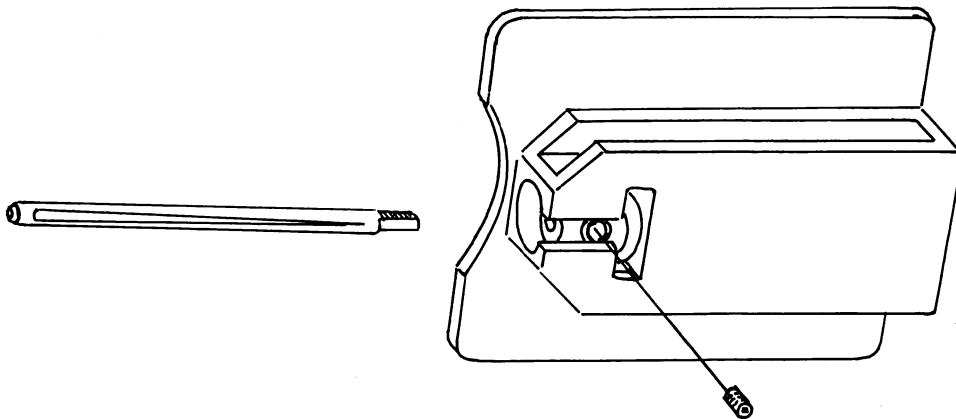


Fig. 10.9 The Lectron carburettor's guillotine throttle valve and metering rod

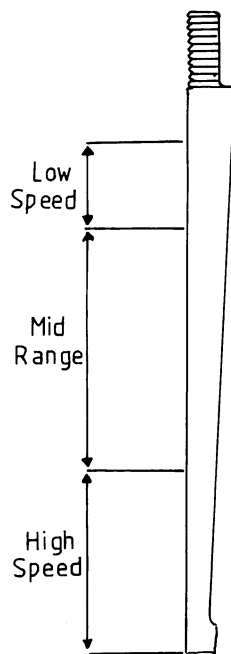


Fig. 10.10 Exaggerated view of Lectron metering rod profile and operating stages

of machines, and have a number of advantages over the paper type. A band or panel of open-celled foam is supported by a suitable frame within the air cleaner casing. The holes in the foam are themselves too big to prevent fine dust from reaching the engine, and the foam's true purpose is to provide a large and intricate surface area to support an oil film. The oily coating is sticky and will trap any passing dust particles, and it is thus the oil, rather than the foam, which does most of the filtering.

The foam element should be removed at recommended intervals for cleaning. It is important to follow the manufacturers cleaning method with care, as the various types of foam used will react differently to various solvents. In some cases, certain commonly used cleaning solvents can dissolve the element, so care must be taken. If in doubt, the safest course of action is to resort to hot water and detergent.

The foam should be squeezed in the solvent or detergent solution until all of the old oil and dirt has been removed. If using detergent, rinse the element thoroughly to remove all traces before it is dried and re-oiled.

The cleaned and dried foam must be re-oiled before it is refitted. The exact grade of oil is not crucial, and most manufacturers recommend an ordinary SAE 30 or SAE 20W/50 engine oil. Some owners prefer to use one of the specially developed air filter oils, as these tend to be particularly sticky, and thus well suited to keeping the air clean. The element should be immersed in the oil, and then the excess squeezed out to leave it damp but not dripping.

A third type of filter is a composite of the first two, and is most commonly found as an after-market part rather than original equipment. The best known of these is the K&N filter.

The K&N type of filter consists of a layer or layers of cotton fabric sandwiched between two sheets of aluminium gauze. The resulting composite strip is then folded into pleats like the paper element types, but differs in that it is oil-impregnated. A range

of these filters is available, covering most standard types and also compact clamp-on filters for individual carburettors.

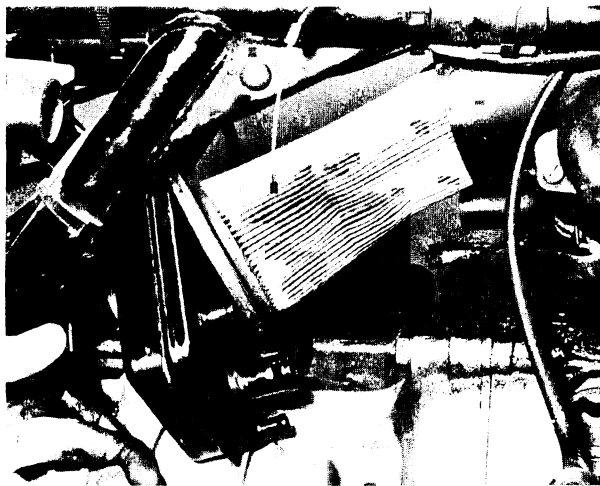
Regardless of the type of filter fitted, it will have a profound effect on mixture strength unless it is in good condition and properly connected. As it becomes increasingly dirty in use, the restriction presented to the incoming air will become greater, resulting in a rich mixture. Whilst this will not cause running problems at first, it will have a noticeable effect on fuel consumption. It follows that regular cleaning and renewal will save money in the long term.

A damaged element or unsound connections between the air filter case and carburettor will not only allow abrasive dust to be drawn into the engine, but will cause the mixture to become weakened. The resultant overheating can prove very damaging and expensive, and should be avoided.

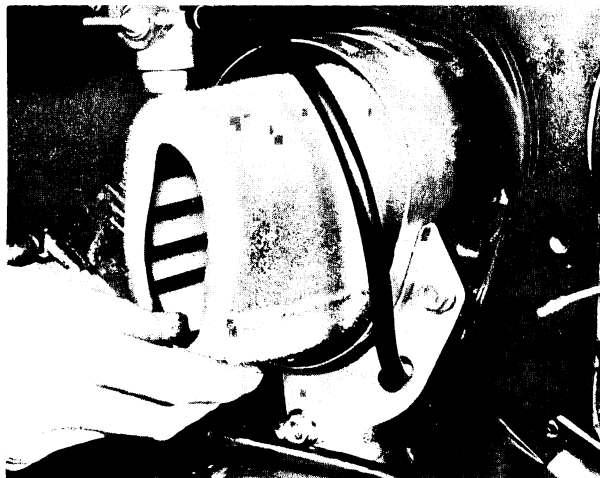
The above remarks should be considered when a standard filter is replaced by a proprietary type. Filters like the K & N offer much less resistance than most factory types, and whilst this is desirable, it will be necessary to re-tune the carburettor(s) with the new filter in place. In some cases re-jetting will be necessary.

## 7 Exhaust systems

Whilst largely outside the scope of this book, exhaust systems deserve some mention due to their effect on carbura-



10.8 Moto Guzzi fit pleated paper elements to their transverse V-twin models

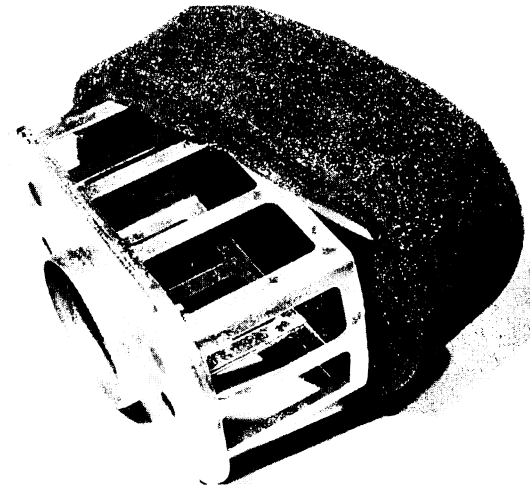


10.10 Filter on the Yamaha YB100 is housed in external metal canister

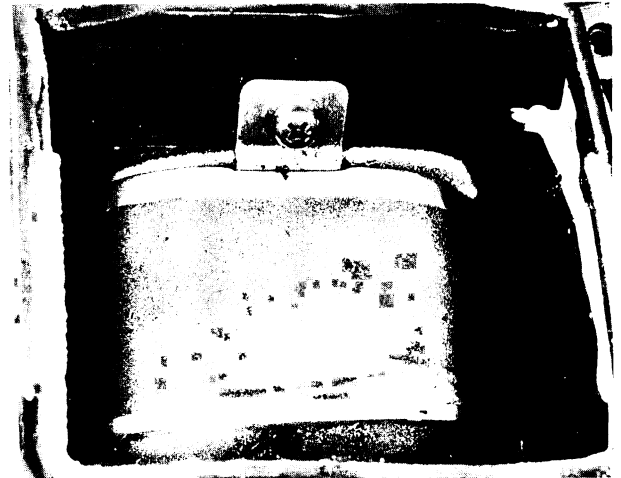
tion. On two-stroke engines, accumulations of carbon around the baffles in the silencer will allow back pressure to build up to the point where performance suffers and carburation is upset. The baffles should be removed for regular cleaning, where possible, to prevent this. On mopeds or other small machines, the tailpipe should be kept clear of obstructions by scraping the loose carbon clear with a length of stiff wire.

A word of caution is necessary when the purchase of an accessory exhaust system is contemplated. Whilst some of these will give a genuine improvement in power at certain engine speeds, some of the cheaper systems do the exact opposite. It should be remembered that the original system was carefully designed to give a reasonable compromise between high-speed and mid-range power, noise and pollution, and fuel consumption. Any change to one of these factors will inevitably affect the others. Most of the more reputable exhaust system manufacturers will be able to produce dynamometer figures to substantiate and clarify their claims of increased power, and it is wise to check this before buying.

Because the new system will have some effect on carburation, go through the tuning sequence to establish what jet changes may be required. The exhaust system manufacturer should be able to offer advice as to what changes are likely to be necessary, and indeed, where the more popular systems are concerned the manufacturer may have precise information on re-jetting.



10.9 Oil-impregnated foam elements are very popular



10.11 On larger machines, the element usually resides beneath the seat (Suzuki GS750)



10.12 Simplest of all filters is the oiled gauze type

### 8 Air cut-off valve

The current move towards weaker mixtures in the interests of reduced hydrocarbon emission has caused one or two minor side effects to become apparent. One of these is a tendency for backfiring to occur when the machine is on the over-run (decelerating with the throttle(s) closed). This is caused by unburnt fuel being ignited by the hot exhaust pipe, and is similar to the condition caused by air leakage at the exhaust pipe joint.

On many new Honda models, the Keihin carburettors have been equipped with an air cut-off valve which partially shuts off

the air supply during deceleration. The valve is of the diaphragm type, very similar in construction to an accelerator pump, and is normally mounted on the side of the instrument.

Little maintenance should be required, but if backfiring symptoms suddenly appear, check that the diaphragm has not split, and thus allowed air to be drawn into the exhaust system. In the unlikely event the valve jams open or closed, its effect will be to allow backfiring on overrun, or to cause poor acceleration in the case of the latter. If either condition is suspected remove and clean the valve plunger/diaphragm and note whether any improvement is obtained.

### 9 Powerjets

The concept of a powerjet arrangement has featured on Lectron, and more recently Amal, carburettors. It is designed to overcome a problem inherent with the use of large bore instruments on competition two-stroke engines. In these applications, a very large main jet is normally used to provide full power at the large throttle openings. A side effect of this is an over-rich mid-range mixture, and as a result, poor running and response.

The powerjet is a subsidiary fuel system designed to augment the fuel supply at high engine speeds, allowing a smaller main jet to be used. In the examples quoted above, the jet in the carburettor bodily discharges via a tube projecting into the centre of the carburettor bore, on the atmospheric side of the venturi. At low speeds the powerjet has no effect, and its discharge tube cannot interfere with the normal airflow.

At the time of writing, each of the two systems available is supplied as an option to the standard arrangement or as a conversion kit. If it proves successful, it is likely that it will eventually become a normal feature on most competition two-stroke machines.

# Chapter 11 Tuning Methods and Aids

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## 1 Introduction

In the previous Chapters, it has been made clear that one or two pieces of specialised equipment would be either useful or essential to the owner who wishes to tune and maintain his motorcycle's carburettors. This is especially true of the multi-cylinder, multi-carburettor arrangements, where smooth and efficient running depends heavily on accurate tuning.

As most owners will not wish to spend large sums of money on elaborate and infrequently-used test equipment, such items have been ignored. Most of the more specialised tools are designed to make the commercial servicing of motorcycles more efficient, and so can be considered labour-saving devices. The equipment described here cannot be categorised in this way, and a vacuum gauge set must be treated as being essential to those who own any multi-cylinder four-stroke.

The Colortune 500 will prove invaluable to any motorcyclist concerned with the efficient running of his machine. Whilst tuning is quite feasible without it, the convenience and accuracy it imparts in use more than outweigh its relatively low purchase price.

## 2 Vacuum gauge sets

As already mentioned, machines using three or more carburettors cannot be set up accurately using the same tuning sequence as that described for single- and twin-cylinder engines. To compound the problem, all multi-carburettor arrangements are particularly sensitive to small discrepancies in synchronisation. Constant depression instruments are particularly difficult to set up visually, because it is impossible to check that the pistons of each instrument move in synchronisation.

The object of synchronising carburettors is to ensure that the same volume of air is fed to each cylinder, and to achieve this accurately it is necessary to measure the depression which exists in each inlet tract at a given engine speed. Most multi-carburettor arrangements have a take-off point on the engine side of each carburettor. This normally takes the form of a tapped drilling which is blanked off with a small screw during normal use.

Vacuum gauge sets can be obtained from a variety of sources. The appropriate equipment can be obtained through most motorcycle dealers. It will normally be necessary to order this, as it is listed as a service tool and will not be kept in stock. The main advantage of this method is that the vacuum gauge

set supplied will be designed specifically for use on the machine in question, and consequently all necessary fittings will be supplied. Unfortunately, equipment obtained in this way will tend to be somewhat more expensive than the 'universal' types available from large accessory stockists.

The latter can also be obtained by mail order from a number of companies which advertise regularly in the motorcycle press. The sets are supplied with from one to six gauges, depending on their application, and include the necessary fittings to suit the majority of installation requirements.

There are two basic types available, both being equally suitable and similarly priced. The first type is known as a manometer, and consists of glass or plastic tubes containing mercury. A flexible plastic tube connects each column to the inlet manifolds of the carburettors. The second type uses a clock-type vacuum gauge, generally one per carburettor, but occasionally a single gauge is used with a selector valve connecting it to each of the carburettors in turn. In all cases, some form of damping valve is fitted to offset the pulsing effect caused by the engine.

It must be stressed that many of the common automotive types are unsuitable for motorcycle use, because these often have adaptor arrangements to connect to the atmospheric side of the carburettors. Whilst they might work acceptably well, there is usually insufficient room to mount the rather bulky adaptor. For this reason, it is advisable to favour those sets which are designed specifically for motorcycle use.

## 3 Making up a vacuum gauge set

If cost is an important factor, it is quite possible to make up a usable vacuum gauge set in the workshop, using easily available materials. Most of the parts required are available in the average town, and the construction of the set is not beyond most motorcyclists. The parts required are as follows

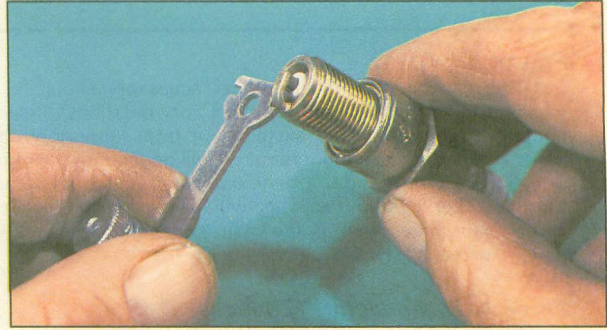
### *The gauges*

One or more vacuum gauges; these are easily obtained from most car accessory shops or similar sources. They are supplied for dashboard mounting in cars, and are quite adequate for our purpose. A wide range is available, and a certain amount of shopping around should soon unearth a reasonably priced instrument. It is quite feasible to set up six or four carburettors using one gauge, as will be seen, although some owners may wish to make up a set which has one gauge per cylinder. This will of course add considerably to the cost.





**Electrode gap check** – use a wire type gauge for best results



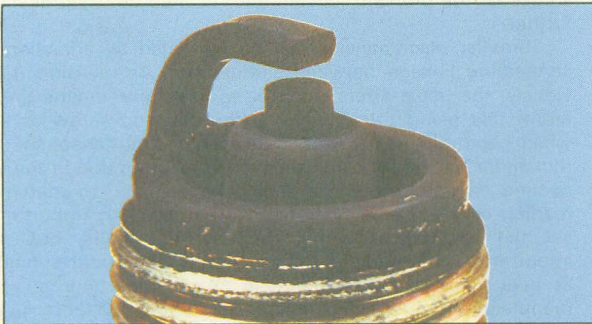
**Electrode gap adjustment** – bend the side electrode using the correct tool



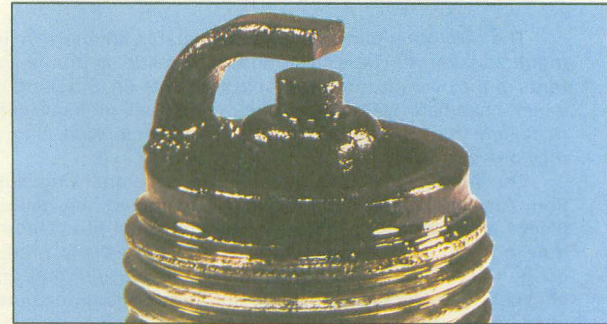
**Normal condition** – A brown, tan or grey firing end indicates that the engine is in good condition and that the plug type is correct



**Ash deposits** – Light brown deposits encrusted on the electrodes and insulator, leading to misfire and hesitation. Caused by excessive amounts of oil in the combustion chamber or poor quality fuel/oil



**Carbon fouling** – Dry, black sooty deposits leading to misfire and weak spark. Caused by an over-rich fuel/air mixture, faulty choke operation or blocked air filter



**Oil fouling** – Wet oily deposits leading to misfire and weak spark. Caused by oil leakage past piston rings or valve guides (4-stroke engine), or excess lubricant (2-stroke engine)



**Overheating** – A blistered white insulator and glazed electrodes. Caused by ignition system fault, incorrect fuel, or cooling system fault



**Worn plug** – Worn electrodes will cause poor starting in damp or cold weather and will also waste fuel

### *Plastic tubing*

This can be obtained from car accessory shops (screen washer hose), aquarium suppliers or petshops (used in aquarium pump and filter systems) or from laboratory equipment suppliers. The amount required will depend on the number of cylinders involved, but a generous estimate would be about four feet per carburettor. This will allow for the necessary shorter lengths as well as the main connections between the gauge and each cylinder.

### *Three-way connectors (T-pieces)*

These should be available from all the above sources, and can be purchased with the tubing. Again, the number required will depend on the number of carburettors. Purchase one for twin carburettors, two for three carburettors, three for four carburettors, and so on.

### *On-off taps*

These should be obtainable from the tubing supplier, with the possible exception of the car accessory shop. Check that they fit the tubing and that they are effectively air-tight. It is important that they do not leak in use. As a last resort, simple clamps can be used, but try to obtain taps if at all possible, because these are much more convenient to use.

### *Adjustable damping valve*

This need not be any more elaborate than a simple adjustable clamp which can be placed over the tubing to restrict it by varying amounts. This can be obtained from an aquarium supplier or a home-brew or wine making shop. A neater job can be made using an adjustable tap. These are harder to find and more expensive, but will make the device easier to use. It is **essential** to obtain a tap which can be turned on and off gradually – a simple on/off type will not work.

The only other parts required are suitable adaptors to fit the manifold take-off. These can probably be made up from the contents of the average motorcyclist's oddments tin. Sawed-off bolts which have been drilled down their centre will probably suffice, or failing that, a chat with helpful motorcycle workshop staff may prove rewarding.

The set is made up as shown in the accompanying illustration. An added refinement would be to mount the gauge, T-pieces and taps in a suitable wooden or metal box. The result may not be quite as attractive as a commercially produced gauge set, but should prove quite serviceable and much cheaper. The version shown is for use on four carburettor installations, but is easily adapted for two, three or six cylinder use, using an appropriate number of tubes and taps.

Start by fitting a short length of tubing, about four inches or so, to the stub on the back of the vacuum gauge. With any luck, the fit of the tubing on the various connections will be quite tight, but to ensure a leak-free joint, the tubing can be secured with a few turns of locking wire. To prevent the wire from cutting into the tubing, protect it with one turn of PVC tape before the locking wire is fitted.

Fit a T-piece to the open end of the tubing, then fit a short length of tubing, about 1½ inches, to each stub of the T-piece. The remaining T-pieces can be fitted next, and the rest of the tubing divided into four equal lengths. These can now be fitted over the four T-piece stubs, and any adaptors fitted at their free ends.

The siting of the four on/off taps will depend on the type used, and whether the finished gauge assembly is to be housed in some form of casing. As a rough guide, fit the taps about two to four inches from the T-pieces. The damping valve or clamp should be fitted between the first T-piece and the gauge itself.

---

## 4 Using vacuum gauges

Like many other form of carburettor testing or adjustment,

it is important that the engine is thoroughly warmed up. This is best done by riding the machine for a few miles until normal operating temperature is achieved. To gain better access to the carburettors, the fuel tank should be removed. Many professional workshops use a small service tank to effect a temporary supply to the machine, but this can be improvised by fitting greatly extended fuel pipes, and rigging up the machine's tank on a nearby bench. In some cases, the rear of the tank can be propped up clear of the carburettors, and the existing fuel pipes used.

Remove the blanking plugs or caps from the vacuum gauge take-off points, and connect the vacuum pipes. Arrange the gauge assembly in a position where it is easily read, and in the case of the mercury column type, in a vertical position.

Start the engine, and note the behaviour of the mercury columns or gauge needles. If the home-made array is being used open one of the on/off taps. The columns or gauges will reflect the engine pulses, and it is necessary to damp out this effect before an accurate reading can be taken. Gradually close the damping valve(s) or clamp(s) until the flickering movement is reduced to about 2 cm (0.8 in) Hg (Hg is the chemical symbol for mercury, and this terminology is carried over in the calibration of clock-type gauges).

Once the gauges or columns have been effectively damped, compare the reading shown for each cylinder. In the case of the single gauge arrangement open and close each tap in turn, checking one cylinder at a time. The exact nominal reading should be checked in the manufacturer's specifications. These are often given in the machine's handbook, or failing that in the appropriate workshop manual. A common reading is something in the region of 20 – 25 cm Hg (7.9 – 10.0 in Hg). If one gauge or setting shows abnormally low vacuum on one cylinder, say 15 cm Hg (6.0 in Hg) or less, an air leak should be suspected. If necessary, the test should be temporarily abandoned, and the source of the problem located and rectified before proceeding further.

Smaller discrepancies can be corrected by adjusting the connecting linkage between carburettors. As mentioned previously, the usual arrangement is to have one 'master' instrument, this being fitted with the throttle stop screw or knob which controls all of the instruments simultaneously. The remainder have a synchronising screw incorporated in the connecting linkage, and these should be adjusted to match the reading of the master instrument. It is obviously important to set the vacuum to within the specified limits, but more importantly, the readings between each instrument should be as near identical as it is possible to get them. Normally, the manufacturer will specify a tolerance of about ± 2.0 cm Hg (0.8 in Hg). Needless to say, the better the synchronisation, the smoother the machine will run. It is significant to note that poor synchronisation on any high performance multi-cylinder machine will cause roughness, vibration and even mechanical noise due to backlash, so the importance of this operation cannot be stressed too highly.

When the synchronising operation has been completed, it is probable that the idle speed will be too high, and this should be set back to normal by means of the throttle stop control. Open and close the throttle a few times, then allow the engine to settle down and re-check the vacuum readings. If necessary, the operation should be repeated until consistent synchronisation is obtained.

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## 5 Checking vacuum gauges

If the operation of one of a set of gauges is suspect, it can be checked as described below. It is recommended that all vacuum gauge sets are checked periodically in this way to ensure that spurious readings are avoided. It follows that a system using one gauge with a selector valve, or the home-made arrangement described earlier do not require checking for obvious reasons.

Warm up the engine, and allow it to idle normally. Connect

one gauge to an outside carburettor, screw down the damping valve or clamp and note the reading shown. Disconnect the gauge, and connect the next tube to the **same** carburettor, again noting the reading shown. Repeat the operation with the remaining gauges, connecting each in turn with the same instrument. The reading shown should be the same in each case if the set is operating correctly. If this is not the case, it is likely that one of the instruments is leaking internally, and this will necessitate its renewal. If the problem appears to be inaccurate calibration, this should be noted, and an appropriate correction factor used when subsequent synchronisation checks are made.

#### 6 Vacuum synchronisation – variations

Although the procedures outlined in the foregoing sections will be applicable to most machines, there are inevitably a few exceptions. Space precludes dealing with these individually, but it is possible to give some indication of likely variations.

On some machines, the method of adjustment may not be by means of synchronising screws in the operating linkage. In

these instances, some form of individual adjustment is provided on each carburettor. On the various Honda four cylinder models, for example, a number of systems have been applied. On the CB750 K1, the adjustment was made via throttle stop screws in the carburettor body, whilst on the K4 version a linkage was employed, operating the four throttle valve through-rods. In this case, the rods were threaded and an adjuster nut fitted at the end. By 1977, the carburettors were of the now common rocker arm type, and the synchronising screw and locknut were located at the end of each rocker arm, beneath the carburettor top.

The adjustment method tends to change with bewildering frequency, and the only safe course of action is to examine the installation to be checked, and establish which are the synchronising screws before work is started.

Some vacuum gauge sets supplied as factory service tools may differ from the two main types discussed. Suzuki, for example, tend to favour steel balls in glass tubes, the method being to adjust the carburettors until each ball is level with the central inscribed line on each tube. The principle remains similar, and where unfamiliar types are encountered, check with the operating instructions before starting work.

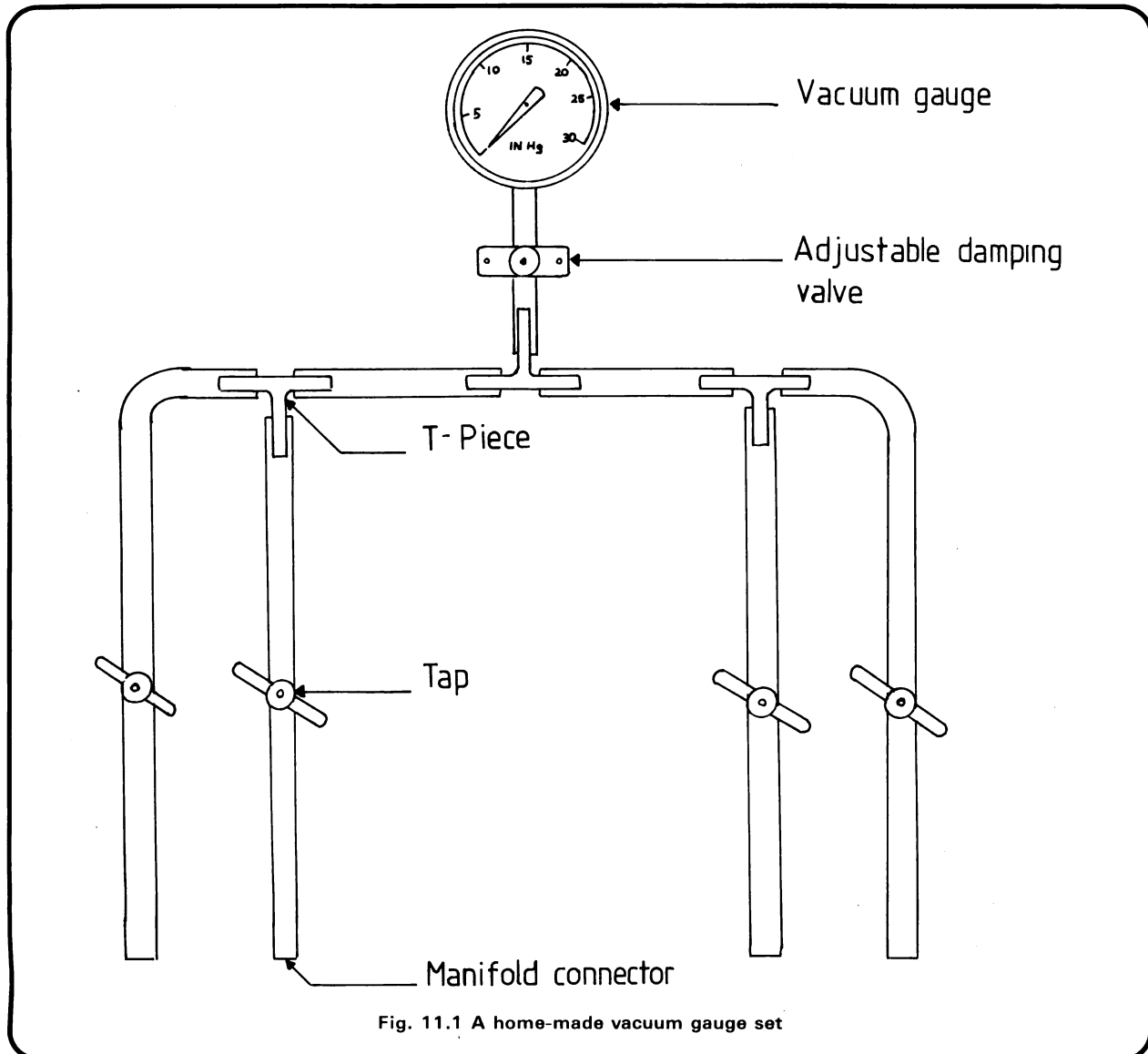
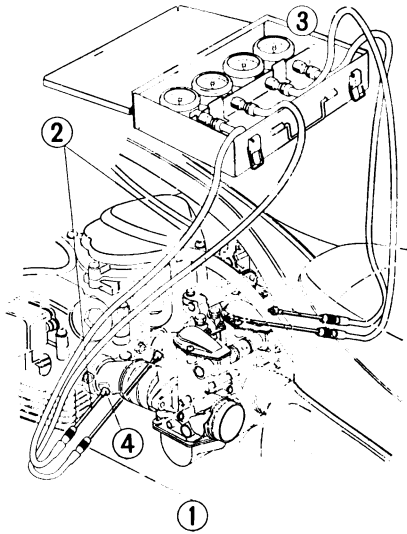
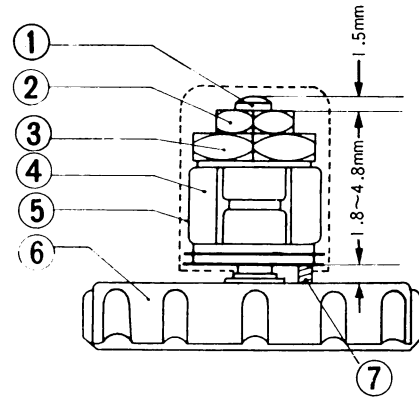


Fig. 11.1 A home-made vacuum gauge set



**Fig. 11.2 Workshop vacuum gauge set in use on a Honda 750**

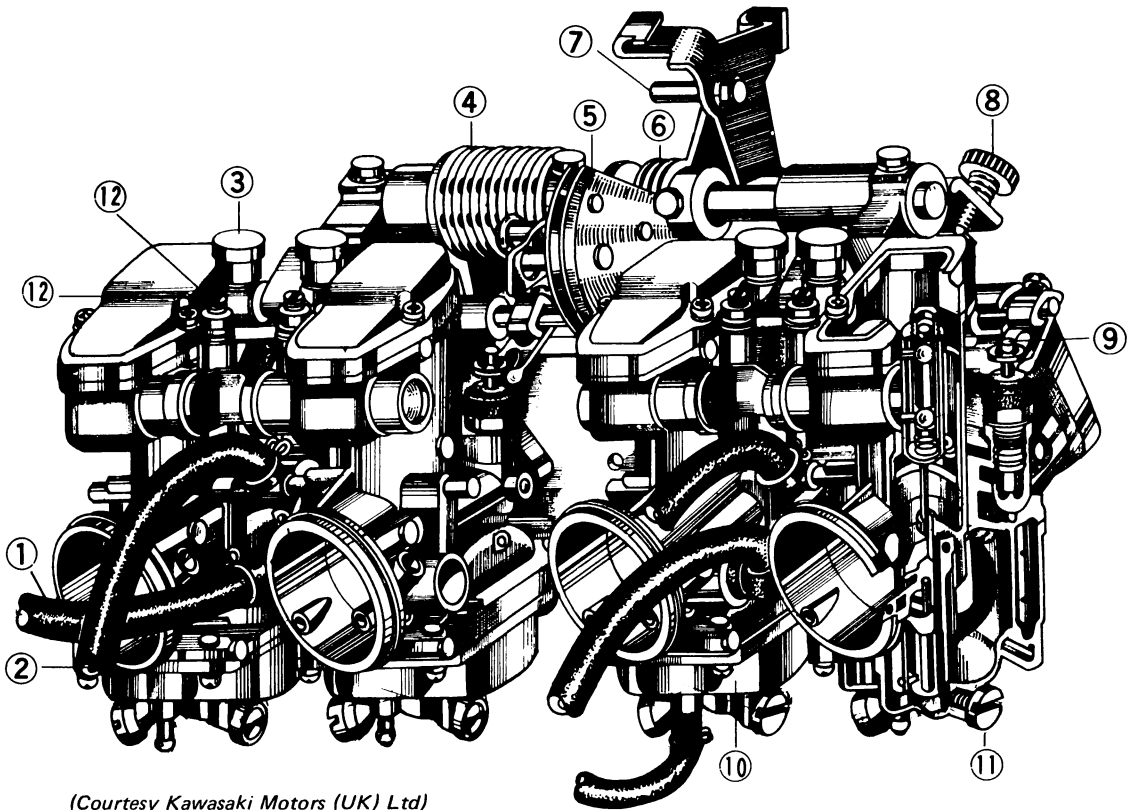
- |                   |                    |
|-------------------|--------------------|
| 1 Adaptors        | 3 Vacuum gauge set |
| 2 Connecting pipe | 4 Manifold thread  |



**Fig. 11.3 Honda CB750K4 throttle synchronisation**

On the rod operated slide carburettor, shown in Fig. 11.8, individual throttle valve adjustment is provided by an adjuster and locknut at the top of each operating rod.

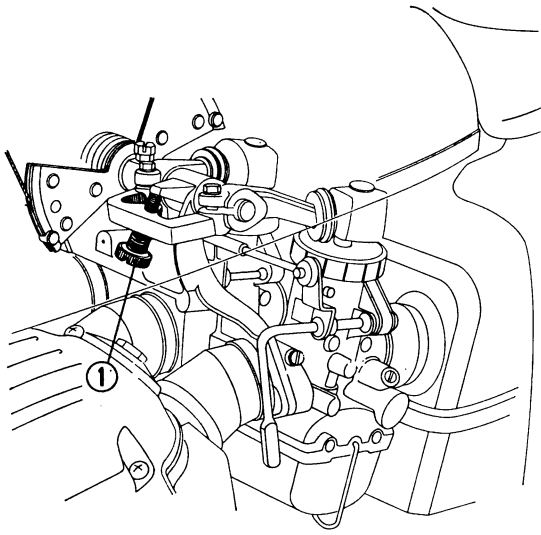
- |                  |                    |
|------------------|--------------------|
| 1 Rod            | 5 Rubber dust seal |
| 2 Locknut        | 6 Carburettor top  |
| 3 Adjuster nut   | 7 Feler gauge      |
| 4 Operating link |                    |



(Courtesy Kawasaki Motors (UK) Ltd)

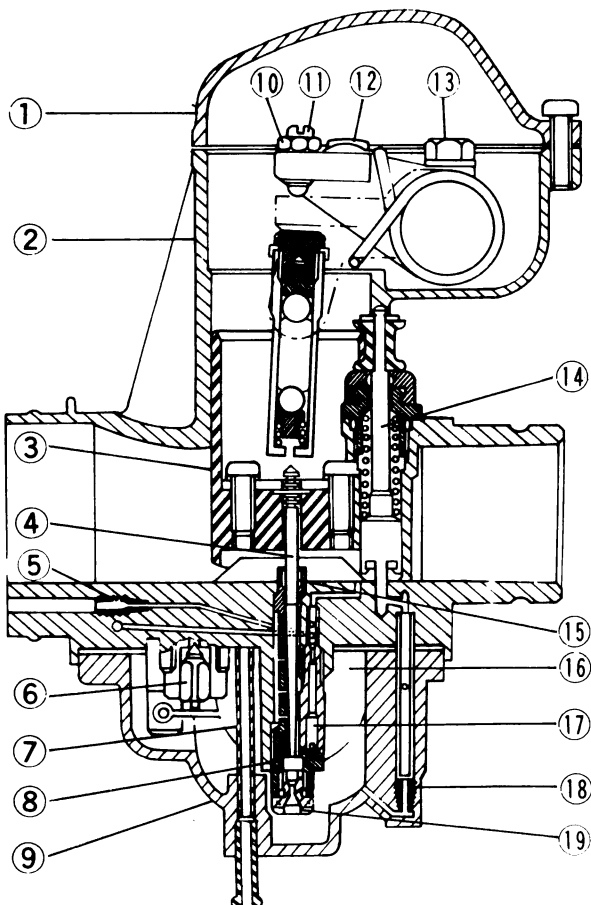
**Fig. 11.4 Early type rocker-arm operated slide carburettor assembly - Kawasaki Z900**

- |                 |                              |                                 |
|-----------------|------------------------------|---------------------------------|
| 1 Fuel pipe     | 5 Pulley                     | 9 Cold-start plunger            |
| 2 Vent pipe     | 6 Crossover spring           | 10 Float bowl                   |
| 3 Guide screw   | 7 Stop                       | 11 Drain plug                   |
| 4 Return spring | 8 Master throttle stop screw | 12 Individual throttle adjuster |



**Fig. 11.5 Honda CB750K4 throttle stop adjustment**

*After synchronisation, all four throttle stop positions are set using a master throttle stop control knob (1).*



**Fig. 11.6 Cross section of later rocker arm slide carburettor – note internal adjustment**

- |                  |                    |
|------------------|--------------------|
| 1 Top cover      | 11 Adjusting screw |
| 2 Mixing chamber | 12 Lock bolt       |
| 3 Throttle valve | 13 Bolt            |
| 4 Jet needle     | 14 Starter plunger |
| 5 Air jet        | 15 Needle jet      |
| 6 Valve needle   | 16 Float           |
| 7 Overflow pipe  | 17 Pilot jet       |
| 8 Air Bleed pipe | 18 Starter jet     |
| 9 Float chamber  | 19 Main jet        |
| 10 Locknut       |                    |

*(Courtesy Kawasaki Motors (UK) Ltd)*

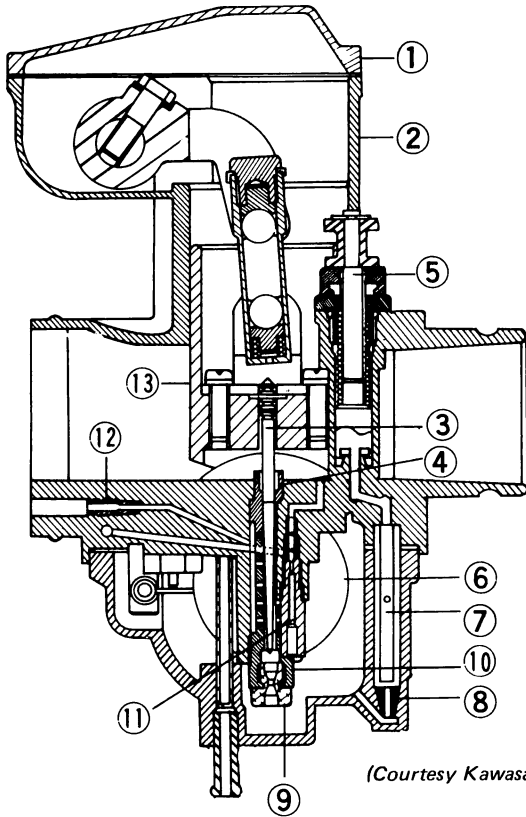


Fig. 11.7 Cross section of rocker arm type slide carburettor with external adjustment

- 1 Carburettor top
- 2 Main body
- 3 Jet needle
- 4 Needle jet
- 5 Cold start plunger
- 6 Float
- 7 Starter feed passage
- 8 Starter jet
- 9 Main jet
- 10 Emulsion tube
- 11 Pilot jet
- 12 Air jet
- 13 Throttle valve

(Courtesy Kawasaki Motors (UK) Ltd)

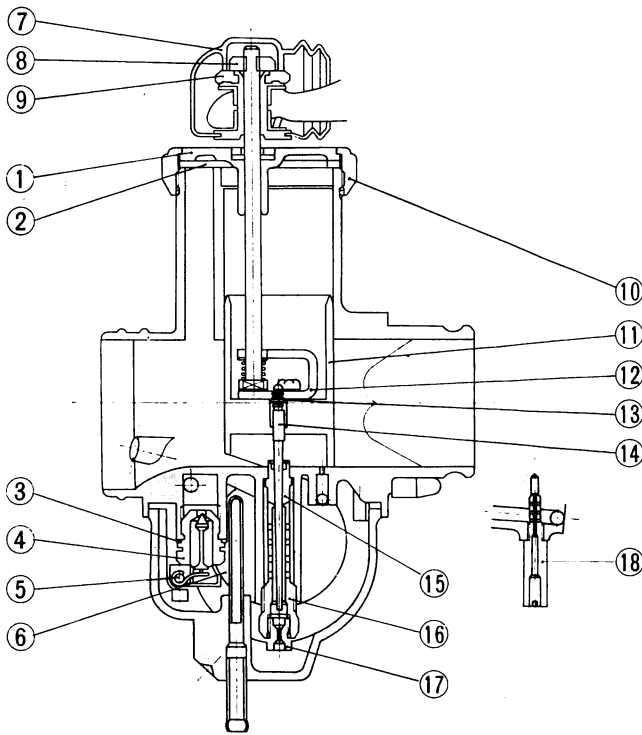


Fig. 11.8 Rod operated slide carburettor  
- Honda CB750K4

- 1 Carburettor top
- 2 Washer
- 3 Washer
- 4 Float valve set
- 5 Float pivot pin
- 6 Float
- 7 Dust cover
- 8 Locknut
- 9 Adjuster
- 10 Cap
- 11 Throttle valve
- 12 Needle retainer
- 13 Needle clip
- 14 Jet needle
- 15 Needle jet
- 16 Needle jet holder
- 17 Main jet
- 18 Slow running jet

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## 7 Obtaining accurate mixture settings

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When the carburettors are set up by the manufacturer, or the machine is serviced by a large dealer, a sophisticated diagnostic machine is employed to obtain accurate settings of all the ignition and carburation functions. By using this type of equipment, the mechanic can set the machine's engine with great accuracy and in the shortest possible time. For the home mechanic, expensive equipment of this type is out of the question, and some other means of obtaining accurate carburettor setting must be sought. We have seen how a vacuum gauge set is used to synchronise a multi-carburettor arrangement, and how this can be used on twin-carburettor machines to obtain a higher degree of accuracy than is possible by the normal trial and error method.

On a single- or twin-cylinder engine, it is possible to set the mixture ratio with tolerable accuracy, using the method described in the tuning chapter related to the carburettor(s) in question. In the case of machines with three or more cylinders, this is less straightforward, and will require some means of assessing the mixture strength if reasonable accuracy and fuel economy is to be expected. Naturally, this can be applied to machines with fewer cylinders, as these too will benefit from precise adjustment.

More importantly, legislation governing exhaust gas emissions is becoming increasingly stringent, to the extent that in some US states, it is illegal to make unauthorised changes to carburettor settings or specifications. Most manufacturers now tend to produce machines on which the idle mixture is described as 'pre-set', and stress in their service manuals that this setting must not be altered by the dealer or owner.

Whilst this is fine in theory, all mechanisms wear, and in time engine and carburettor wear may demand some compensation in adjustment to maintain reasonable overall performance. In some cases, the uncorrected mixture settings may cause more harmful exhaust emission levels than those permitted by law, and so leave the owner with something of a dilemma. It is not the wish of the author to condone infringements of this legislation, and the tuning sequences described here are left to the discretion of the individual. The following sections describe the method for obtaining accurate mixture settings where conscience and local legislation permit.

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## 8 The Colortune 500

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When a fuel/air mixture is burnt in the cylinder of an engine, it does so with a flame the colour of which relates directly to the mixture ratio. This phenomenon is not confined to the internal combustion engine, and is demonstrated admirably by blowlamps, bunsen burners and paraffin (kerosene) heaters.

When the fuel/air mixture is correct, the flame produced is a rich blue colour, denoting that air and fuel are present in the correct quantities to allow all the fuel to be burnt without an excess of air being present. This is of vital importance in any engine, because efficiency and power fall off dramatically if there is an excess of either air or fuel in the cylinder.

If there is a deficiency of air, the resulting flame will be a yellowish-white colour, and will produce a great deal of carbon due to the incomplete combustion of the fuel. In an engine, the same conditions exist if the air supply is restricted or the fuel/air mixture is too rich. As the mixture is weakened, either by supplying more air or less fuel, the flame colour will suddenly change to blue, indicating that the ratio of fuel and air is correct. Further weakening of the mixture will cause the flame colour to change progressively from a rich blue to a thin bluish-white. This is fine for blowlamps, as it means that an intensely hot flame is being produced. In engines, however, excess heat is far from desirable, and is often responsible for holed pistons and pre-ignition. It will be appreciated that the rich blue colour is indicative of a good balance of air and fuel, and is therefore

exactly what we require in our engine.

From the foregoing it can be seen that it would be very useful indeed if it were possible to observe combustion taking place inside the cylinders of our engine. Particularly useful is the sudden colour change from yellow to blue as the mixture strength moves from rich to normal. If we were able to observe this taking place as the pilot air screw was adjusted, it would be a very simple matter to find the right mixture strength, even without screw settings or other data.

This is by no means a new notion, and for some years, various engine tuners have experimented with finding a way to provide a window through which the combustion flame could be observed. It was quickly realised that the sparking plug was the obvious method. If the porcelain insulator were replaced with a glass equivalent, an instant window would result. The main problem was that the sudden temperature change usually cracked the glass. This was overcome by the use of a heat-resistant glass, and by making the window as small as possible to counter the affects of differential expansion. This in essence, is what the Colortune is.

Developed by Gunson's Colorplugs Ltd, the Colortune 500 consists of a machined metal body, very similar to the type used in conventional sparking plugs. Inside the body is a bonded heat-resistant glass window, through the centre of which is a small ceramic sleeve which carries the centre electrode. The centre electrode terminates in a fixed 0.025 in electrode gap between it and the metal body, which provides the connection to earth. The plug is supplied in a kit which includes a re-usable sealing washer, an extension HT lead and adaptor, cleaning fluid and brush, and a special viewing tube with an adjustable mirror to facilitate use with awkwardly-placed plugs. An optional range of adaptors is available to convert the standard 14 mm thread to 14 mm long reach, 18 mm plain and taper seats and 12 mm and 10 mm. The plug cannot be used on  $\frac{3}{8}$  in hexagon 'bantam' type plugs.

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## 9 Using the Colortune 500

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The Colortune 500 can be used to good effect on almost any motorcycle, assuming that suitable adaptors are obtained where required. Because the device was designed primarily for automotive use, there are one or two minor limitations which should be noted.

On some machines, the area immediately above the sparking plug threads is rather restricted, and it is often impossible to fit the 'viewerscope' attachment unless the fuel tank is removed. This can be overcome by fitting the device without the viewerscope, and using the mirror end of the latter as a means of reflecting the image of the combustion flash. This can be rather unwieldy without an extra pair of hands, but some improvised method of mounting the mirror in a convenient position can usually be found. In the author's experience, plasticine, wire and PVC tape can be very useful for this.

Most motorcycle engines are air-cooled, and thus cylinder head temperatures tend to be higher than those of water-cooled engines. For this reason, tests made above idle speed should be of limited duration, generally not more than three minutes. Although the device is able to withstand fairly high temperatures, it will be damaged if exposed to too high a temperature.

### *Testing at idle speed*

As with all carburettor tests, it is important that the engine is at its normal operating temperature before any testing operations are undertaken. The best way to ensure this is to ride the machine for a few miles prior to testing. It is advisable to park the machine out of direct sunlight to enable the flame colour to be seen clearly. If the test is to be performed in a garage or workshop, make sure that the doors are left open to avoid any danger of the build-up of toxic exhaust fumes. It should be noted that on multi-cylinder machines, the carburettors **must** be synchronised before the mixture is adjusted.



11.1 The Colortune 500 fitted to a BMW

Remove one sparking plug, and fit the Colortune plug, using the large sealing washer, and also a thread adaptor where necessary. Be careful not to overtighten the plug, little more than finger-tightness will be enough to ensure an adequate gas seal. Screw on the HT adaptor lead, fitting the threaded pin in the free end if required. Where possible, the viewerscope attachment should be fitted to shade the plug and allow the mirror end to be used. Where space precludes this, arrange the viewerscope mirror so that the glass window can be seen clearly. Connect the machine's plug cap to the end of the extension lead, then start the engine.

With the engine running, it will be possible to observe the flash as each successive charge is ignited in the cylinder. Turn the throttle stop screw so that a slow but even tickover is obtained. The pilot mixture screw should now be turned (usually clockwise) until the colour shown is a bright yellow, denoting a rich mixture. On machines with limiter caps on the mixture screw, it may prove necessary to remove the cap to allow the yellow flame colour to be obtained. Slowly turn the screw back until the flame colour turns blue. This will happen quite suddenly, so move the screw a fraction at a time. This setting will give the optimum idle mixture for instruments other than emission control types.

In the case of emission control instruments, continue weakening, whilst watching the flame colour and noting the sound of the engine. The flame colour will become progressively less bright until a point is reached at which the engine will start to falter due to excessive weakness. Make a note of the arc described by the screw between this over-weak setting and the initial 'bunsen-blue' colour. The mixture screw should be set half way between these extremes. When adjustment is complete, refit the limiter cap at the mid-point of its range, where appropriate.

The engine can now be stopped, and adjustment carried out in a similar manner on the remaining cylinder(s) where appropriate. It may be that adjustment proves difficult, or even impossible, due to erratic changes of colour which make it impossible to establish the point of transition between yellow and blue. This is indicative of a number of faults which are discussed later in this Chapter. If this sort of problem is evident, refer to Section 9 before attempting further tuning.

### *Testing above idle speed*

Having set the idle mixture as described above, it is possible to use the Colortune to check mixture strength at intermediate throttle settings, and during the transition stages between idle and intermediate. The tests should be made on each cylinder in turn, where appropriate. Reference should also be made to the

diagnostic chart supplied with the Colortune kit in which the likely causes of any anomalies in mixture strength are discussed.

With the Colortune connected as before, gradually increase engine speed from idle to about 3000 – 4000 rpm, over a period of about ten seconds. The engine speed is not of prime importance, but the throttle(s) should be opened evenly and progressively. The flame colour should change progressively as the engine speed increases, becoming less luminous, but remaining blue.

Allow the engine to return to idle, then snap the throttle(s) open, closing them again at about 3000 – 4000 rpm. During the period from rest to 3000 – 4000 rpm, the flame should be bright yellow, this colour disappearing as the engine 'catches up' with the throttle setting.

High-speed operation cannot be checked in safety, as the engine should not be taken to maximum speed in an unloaded condition. It is also likely that the Colortune would sustain damage if used in this way. High speed running can be checked by assessing sparking plug colour after a high-speed run, as described earlier in this book. Note that on no account should the machine be ridden with the Colortune in place.

When testing is complete, remove the Colortune plug carefully, taking care to avoid burnt fingers. When it has cooled down, clean the plug as described in the manufacturer's instructions.

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## 10 Using the Colortune 500 as a diagnostic aid

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In the preceding sections, the construction and use of the Colortune 500 was discussed, and some indication was given of the way the device can highlight particular problems in the carburettor. In practice, the test plug will be found to be very sensitive to variations of mixture strength at any given setting, and with a little experience, the general condition of the instrument(s) can be assessed prior to overhauling. It will be appreciated that this can save a great deal of time, and can avoid expenditure on the renewal of parts which might prove to be quite sound.

Included in the test kit is a diagnostic chart which illustrates how various anomalies in the flame colour can often be traced to wear or maladjustment of specific components. The plug can also be used to detect some forms of engine wear by drawing attention to the presence of excess oil in the combustion chamber, and can be used to set the static ignition timing.

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## 11 Carburettor synchronisation without vacuum gauges

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The various three-cylinder two-stroke machines, which were abundant at the beginning of the 1970s, but have now all but vanished, required a slightly different approach to synchronisation. The factory recommendation was that a similar approach be adopted to that described earlier for twin-cylinder arrangements.

The water-cooled Suzuki GT750 employed a bank of three constant depression carburettors of Mikuni manufacture. Initial synchronisation is carried out by adjusting the two synchronising screws until the upper edge of each butterfly valve aligns with the No 1 bypass hole in the carburettor choke. Having checked the mechanical synchronisation, the engine should be warmed up, and the idle speed control set so that the engine runs at 3000 rpm. Isolate the left and centre cylinders by removing the sparking plug caps, start the engine and adjust the appropriate synchronising screw so that the engine runs at 1000 rpm on the right-hand cylinder only.

This operation is repeated with the left- and right-hand cylinders isolated, and then with the centre and right-hand cylinders respectively. Then with all sparking plugs connected, the idle speed control is backed off to obtain an idle speed of 1000 rpm with all cylinders firing.



The smaller GT380 and 550 models require a different procedure, because slide-type carburettors are fitted. To check the mechanical synchronisation, it is necessary to set the idle speed control knob to  $1\frac{1}{2}$  turns out from its fully bottomed setting. The individual throttle valve adjuster nuts are now used to set each valve so that the clearance between the main bore and the underside of the valve is 0.8 – 1.0 mm. The full-open stop screws are then set so that the far edge of the valve is 0.5 – 1.0 mm above the edge of the main bore with the throttle held fully open.

The final synchronisation is done with the engine running on two cylinders. One sparking plug cap is removed after the idle speed control has been set to give an engine speed of 1500 rpm. One carburettor is then set to give an idle speed of 1000 rpm, and the procedure is repeated with another cylinder isolated. The sequence is as follows:

- Isolate the right-hand cylinder and adjust the centre one.
- Isolate the centre cylinder and adjust the right-hand one.
- Isolate the left-hand cylinder and check engine speed.
- Isolate the right-hand cylinder and adjust the left-hand

cylinder to the same speed as noted at stage c.

- Connect all cylinders and set the idle speed to 1100 rpm.

The above examples illustrate anomalies, in that the manufacturer advises a synchronisation method which avoids the use of vacuum gauges, mainly due to the machines in question being two-strokes. The latter example is a sequence of adjustment and engine speed comparison with two out of three cylinders in operation. If necessary, a similar sequence can be devised for other machines, although it will be appreciated that a four-cylinder arrangement will give rise to a greater number of permutations, and will therefore be rather time-consuming in practice.

If done conscientiously, this sort of sequence can produce results which compare favourably with those obtained with a vacuum gauge arrangement, but it must be remembered that very slight discrepancies in ignition settings will give false readings when checking the various engine speeds. For this reason, it is recommended that this system should only be used as a last resort unless it is recommended by the manufacturer as being the correct approach for a particular machine, such as those quoted in the examples.

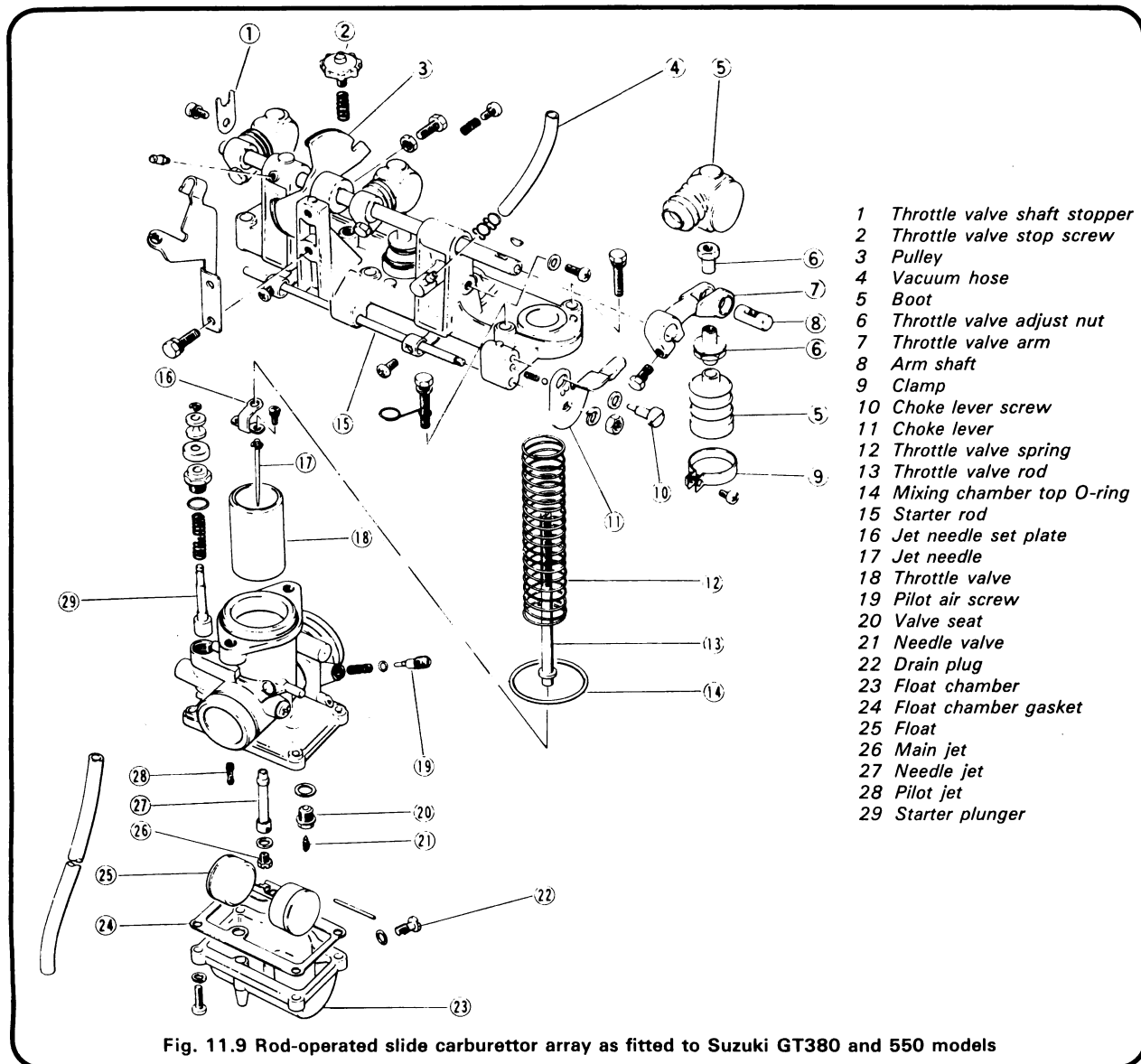


Fig. 11.9 Rod-operated slide carburettor array as fitted to Suzuki GT380 and 550 models

# Chapter 12

## Future Developments – the end of an era?

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For the first time in its long history, the motorcycle has two new and crucial factors to contend with, both of which have a direct bearing on future trends in carburettor design. To date, the main criterion was the extraction of maximum power from a given design. From 1980 onwards, the reality of dwindling oil reserves will mean increasingly expensive fuels for all motor vehicles, and so efficiency and economy will become increasingly important aspects of any future development of carburation.

Of equal importance are the numerous regulations throughout the world which limit the percentage of toxic gases permissible in exhaust emissions. The level of atmospheric pollution is an escalating problem, and can only be dealt with by increasingly punitive restrictions.

During the 1970s the car manufacturers took the lead by producing complicated systems where catalytic converters were used to clean up the exhaust gases. This resulted in cleaner engines, but also made for impaired efficiency and poor fuel economy. Some of the worst examples were depressingly slow, heavy and thirsty, and were often set up to run on such a weak mixture that reliable starting and idling became a thing of the past.

In the motorcycle world, things have not been quite so dramatic, although the overall performance of almost every model can be seen to have declined progressively since about 1975. The dramatic two-stroke triples have been killed off, due to their excessive thirst and incorrigibly dirty exhausts. The ubiquitous four-stroke fours have gradually become more staid in their performance as the manufacturers have fought to meet new laws controlling noise and air pollution.

The float chamber 'tickler' – used to flood the carburettor for cold starting – has disappeared, along with air vent holes, which have now been routed into air cleaner cases or plenum chambers to prevent fuel vapour escaping into the atmosphere. To reduce unburnt fuel levels on overrun, small air bleed valves have been fitted in exhaust systems to assist in burning off any surplus in the exhaust pipes.

This trend is likely to continue into the 1980s, and at the time of writing the newly announced Yamaha XS850 three-cylinder model would seem to provide an indication of what is to come. The carburettors of this model are of the CD type, similar to the Mikuni diaphragm (Stromberg) instruments, but manufactured by Hitachi who have begun development of motorcycle carburettors to support their established range of car instruments. Significantly, most of the adjustable features of current types are absent. The throttle needle has only one position groove, and thus cannot be moved to compensate for different intermediate mixture requirements. The pilot mixture screw is set up during manufacture, and is then covered by a non-detachable metal plug. Even the ignition timing has been fixed by the simple expedient of rivetting the stator to the crankcase.

It follows that servicing of this type of instrument will be restricted to checking the idle speed setting, and where facilities are available, checking carburettor synchronisation.

It is very probable that accelerator pumps will soon become more widely used in motorcycle carburettors. This will enable throttle cut-aways to be reduced, because there will no longer be a need for extra-rich mixture as the throttle is first opened. With an accelerator pump, the carburettor can be made to run much weaker, the pump providing the extra input of fuel when required rather than at all times.

It is possible that automatic cold-start systems will arrive in due course, as this will make it impossible for the rider to run the machine with its extra-rich starting mixture for longer than is strictly necessary. At present, systems of this type are used widely in the car world, but are usually fairly crude mechanical arrangements operated by bi-metal springs responding to engine temperature. In the coming years the silicon chip will inevitably find its way into our electrical systems, and cold-starting mixture adjustment will be an obvious task for it.

The biggest question is that of the long-term fate of the carburettor. To anyone who has read this far, it must have become obvious that a carburettor is a complex assembly of compromises. From the earliest days of its history it was known that a jet can only be effective over a small part of the throttle range, and precisely right at just one throttle setting, engine speed and load. The more complex and sophisticated the engine becomes, so must the carburettor. In this way, a small European moped can make do with its single jet and no needle and needle jet, but on an engine such as Honda's CBX, appropriate carburation is essential.

The legislation that is inevitable during the 1980s will mean that the very existence of the carburettor must be questioned. If each successive law demands another jet and fuel circuit, we will eventually arrive with a hybrid instrument. This compound device will have multiple jets, probably be twin-choke, and possibly be part constant-depression to boot. Apart from its sheer complexity, it will be very expensive to manufacture.

It is at this stage that an electro-mechanical system begins to make sense. It is not difficult to monitor what is going on in an engine. Probes can be fitted to monitor exhaust gas composition, engine temperature, engine speed and loadings and fuel consumption. Add one silicon chip and we can interpret these readings and the chip can then make any necessary changes in the proportion of air and fuel entering the engine to make it cleaner, more efficient and/or faster.

The mechanical end of the system could be a sort of servo-controlled carburettor, with the electronic circuits monitoring and adjusting the mixture strength, or it could control the throttling function as well. The familiar twistgrip could then be an electrically linked rheostat – a device to control the machine's speed but not the way in which it obtains it.

Alternatively there is fuel injection, not as a means of obtaining power, but as a source of precision. Here we need look no further than to Volkswagen cars to find the beginnings of a production line electronic injection system. Developed by Bosch, the system currently is all mechanical, but does compensate automatically to suit the engine's requirements (rather than the driver's). Bosch and a number of other companies are still developing a complete electronics-based system, the question of its appearance being 'when' rather than 'if'.

The motorcycle manufacturers appear to be following this line of development, and in February 1980, Kawasaki announced the first fuel injected production line motorcycle. The new model, designated the Z1000H in the UK., has an electronically-controlled injection system controlled by a micro-processor housed in the seat tailpiece.

The future, then, lies with ultra-sophisticated compound carburettors, or with electronic carburettors or fuel-injection systems, perhaps with both. Either way, it seems that the traditional carburettor may now be nearing the end of an era, as well as a century of development.

## Chapter 13 Fault Diagnosis

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There are two possible carburation faults, namely richness or weakness. Although there are numerous ways in which poor running can be caused at various engine speeds, the problem can always be traced back to one of the two deficiencies described above. This small but significant point must always be considered when attempting to identify the cause of the fault.

It is essential to be methodical when approaching any carburation problem. If a random approach is adopted, it will invariably take longer to find the source of trouble, and unnecessary adjustments to previously correct settings will only serve to mask the fault. Remember also that mechanical or electrical malfunctions can often appear to be symptoms of poor carburation, and care must be taken to avoid confusion in these areas.

The table that follows can be divided into two broad categories. The first covers those faults in which the engine either fails to start, or runs so badly that normal use is not possible. Although these faults will demand immediate attention and are therefore the more urgent in nature, they are generally easy to resolve, and the cause of the trouble can often be embarrassingly obvious.

The second type of problem is less dramatic but no less irritating, and can be defined as those problems which are noticeable but do not directly prevent the machine's continual use. These are usually due to gradual wear in the carburettor or in the machine in general. Unfortunately this category is far more difficult to track down, and is much more common in practice.

*A carburettor fault diagnosis chart follows on pages 116 and 117.*

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**Carburettor fault diagnosis chart**


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Symptom	Likely cause	Remedy
<i>Starting</i>		
1. Engine will not start – no sign of life	No fuel reaching cylinder(s)	Check supply by removing fuel pipe to check flow. Check float valve for blockage. Check jets for obstruction or water contamination. If all appears well, view the ignition system with great suspicion – recheck at once. May be due to failure of sparking plug under compression pressure.
2.	No spark occurring in cylinder	Remove sparking plug, refit HT lead and earth plug against engine. Plug should spark regularly when engine cranked (ignition switch on). Plug may spark during test but fail under compression pressure. Test by substitution. If no spark, test ignition system and timing with great care.
3.	Mechanical fault	Most unlikely, as this would require moderately severe failure. Exceptions may be blown cylinder head gasket, holed piston or burnt out valves (4-stroke only).
4. Engine fires spasmodically or when started, dies almost immediately	Caused by varying degrees of the above. May be caused by combinations of faults.	Check all above, but with extra care as fault will be less obvious. Mechanical failure will be shown by very poor compression. Look for signs of water in fuel. If found, flush entire fuel system and buy petrol elsewhere.
<i>Engine at idle</i>		
5. Engine reluctant to start – will not idle properly	Fuel starvation, blocked pilot circuit, badly choked air cleaner.	Investigate fuel supply as described in 1 and 4 above. Note that water in the fuel will tend to block pilot jet first due to small orifice size. Check that petrol tank filler cap breather is unobstructed by loosening cap and comparing results. Air cleaner unlikely to be responsible unless suddenly contaminated by oil or similar.
6.	Ignition fault	May be due to contact breaker gap closing or timing slipping – check and reset. Partial short or open circuit in ignition coil may cause poor running. Check system as described in 2 above.
7. Engine runs far too rich at idle	Adjustment of pilot screw/pilot jet size incorrect. Float height incorrect.	If problem has developed gradually, check idle system setting(s). Sudden fault indicates blocked pilot air jet or passage. Has pilot jet worked loose or fallen out? Check float system for adjustment or float valve leakage. Temporary fault may have been caused by dirt trapped in valve. Check metal floats for signs of leakage.
8. Engine runs far too weak at idle	Damaged hose between carburettor and air filter. Blocked pilot jet. Wrong valve cut-away chosen. Fuel starvation.	Check carefully for splits in hoses or loose connections. Check for blockages as described in 5 above. Throttle valve cut-away can affect idle performance, but unlikely unless new valve has been fitted recently. Worn throttle valve can allow air leakage and thus weakness.

9. Idle speed inconsistent – engine stalls sometimes	General mechanical wear, carburettor loose on mounting	Check for wear, especially between valve and body. If present, try new valve, if no better, carburettor(s) must be renewed before correct running is possible. Check that carburettor is mounted firmly and that all gaskets and O-rings are sound.
10.	Ignition fault	Quite a likely cause – check as described in 6 and 2 above. Pay particular attention to low tension wiring and connections.
11.	Needle location (CD carbs). Worn butterfly spindle (CD and fixed jet). Overheating (all types). Piston sticking (CD only)	With CD instruments, check that needle is correctly positioned and that piston moves smoothly. Worn butterfly spindle may necessitate renewal of carburettor (see main text). Overheating may be due to omission of insulator block (where this is normally fitted) or to incorrect ignition or valve adjustments.
<i>Engine at intermediate speed</i>		
12. Engine dies or hesitates as throttle is opened	Weakness caused by blocked jet(s) or orifice. Worn needle (especially CD types). Throttle valve cut-away too large. Air leaks.	Check for obstructions as in 1 and 4 above. Examine jet needle for signs of wear or scoring at thickest end – renew if worn, together with needle jet. Check that correct cut-away is fitted. Check for air leaks as in 5 and 8 above.
13. Engine runs heavily or floods	Richness – caused by blocked air jet or bleed tube. Needle position wrong. CD piston sticking. Float bowl flooding. Stromberg-type CD – diaphragm split	Check for obstructions as in 1 and 4 above. Check that needle clip is in correct locating groove. Check CD piston for smooth operation (See 11 above). Check throttle valve cut-away. Check for flooding as in 7 above. Check diaphragm (Stromberg types) for splitting.
14. Engine runs erratically	Check for air leaks at manifold and around throttle valve. Carburettors not synchronised. Water in fuel.	Check for air leaks as described in 4, 8, 9 and 12 above. On twin and multi-carburettor arrangements any imbalance will cause rough running, most noticeable at this engine speed. Check for water in fuel as in 4 above.
15.	Ignition fault	Check system – see 2, 4, 6 and 10 above.
16. Engine gradually fades and stops – will re-start if left for a while	Fuel starvation	Check tank filler cap for obstructions. Dismantle and examine fuel tap for wear or blockage. Check float setting and float valve. Float vent or vent pipe may be blocked.
17. As above – cold weather only	Icing	Rare fault induced by a cooling effect of evaporating fuel. If system is standard, little can be done without devising some means of warming incoming air. Check that air cleaner is connected and clean.
<i>Engine at high speed</i>		
18. Engine pulls poorly – overheats	Weakness	Check main jet size and look for obstructions in passages or drillings. Check float height as in 7 – may be too low. Is float valve and tap passing adequate flow of fuel? Check for air leaks as in 8.
19. Engine runs heavily – poor fuel consumption	Richness	Check main jet size. Check air passages and clean filter element. Choked exhaust system (two-strokes). Flooding or incorrect float height – see 7.
20.	Ignition fault. Mechanical fault.	Check ignition timing and contact breaker gap. Is timing advancing correctly? Check sparking plug grade and type. Check valves (4-stroke) for burning or maladjustment. Is cam timing correct?